NEXT MONTH

It has been some time since *Chem. & Met.* has reported extensively on the means for treating water for use in process industries which use great volumes for processing, to take care of the power plant and process steam requirements, to provide fire protection for the plant, and drinking water for the employees, and for numerous other purposes. In the interval considerable progress has been made in the development of methods and equipment for removing the mineral and bacterial impurities and for controlling the pH. At the same time these industries have been able to determine what effect the various impurities have upon their processes and products. This knowledge has led to the adoption of specifications for water limiting impurities to extremely small amounts. In June the editors will report the progress that has been made in the ways and means of treating water to meet these requirements for industrial purposes.

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ESTABLISHED 1902

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"To me, the secret is..."

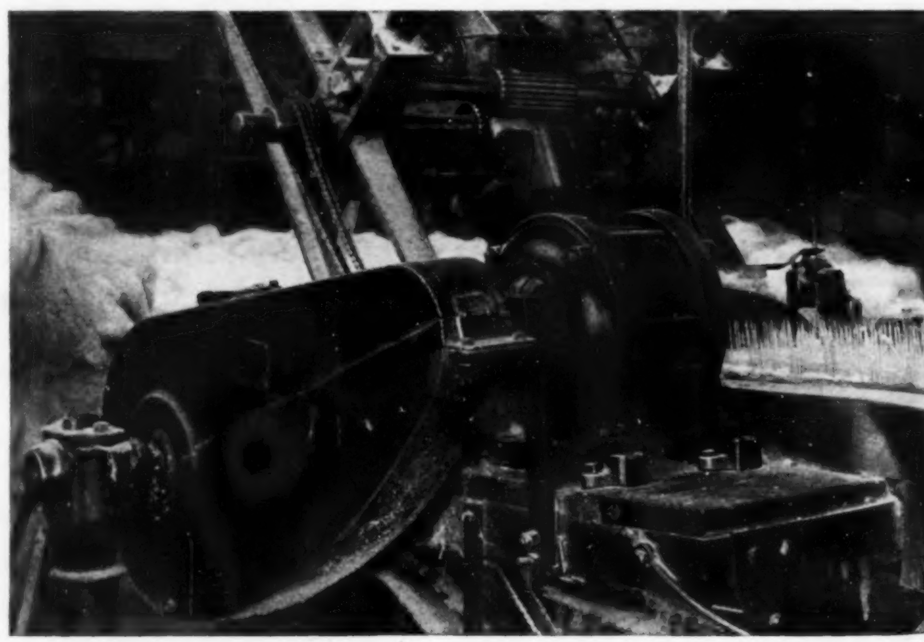
E. H. Swan

WHEN A plant superintendent — with several makes of motors in his factory — speaks right up and states that he prefers *one* make of motor over all others . . . it's a good idea to listen to what he has to say . . .

The speaker is E. H. Swan, Maintenance Superintendent at the Hooven & Allison Company, Xenia, Ohio. And here's what he says —

"We have 81 Allis-Chalmers Motors in our plant. We have a lot of other makes too. But we've never had an Allis-Chalmers motor go back on us in any way. Nor have we had to spend a cent on these motors for repairs or upkeep beyond normal maintenance, and that covers more than twenty years of service.

"To me, the secret is that they're built sturdier. They actually seem to be immune from the costly repairs you get with so many other motors. Believe me, that's why I like Allis-Chalmers motors in preference to any other make."



DRIVING A SPREADER IN THE HOOV
Allison manila rope and twine factory, this
is typical of the 81 Allis-Chalmers Lo-Maint
Motors in this plant . . . motors which ha
up a record of never having cost a ce
repairs or upkeep beyond normal mainte

Lo-Maintenance for Lower Costs!

Mr. Swan is right! Allis-Chalmers Lo-Maintenance Motors *are* built sturdier. For in Lo-Maintenance Motors you get such sturdy, extra-value features as indestructible rotor, distortionless stator, high carbon steel frame. What's more — you get *no skimping anywhere* in materials, design, or workmanship.

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you want in your plant, get the
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near you. Or write Allis-Chalm
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ALLIS-CHALMERS LO-MAINTENANCE MOTOR

CHEMICAL
& METALLURGICAL
ENGINEERING

ESTABLISHED 1902

S. D. KIRKPATRICK, *Editor*

MAY, 1941

FROM AN EDITORIAL VIEWPOINT

WANTED, CHEMICAL MAN-POWER

According to an official compilation of "Ordnance Department Personnel Needed in Critical Positions," the government munition plants during the fiscal year beginning next July 1, are going to need 9,520 technically trained men. These include 5,060 ordnance materials inspectors, 2,645 ammunition and explosive inspectors, 760 chemists, 380 chemical engineers, 240 mechanical engineers, 295 mechanical draftsmen, 105 tool and gage designers, and 35 metallurgists. In view of the fact that almost all the explosives inspectors must have some chemical training, and that many of the ordnance materials inspectors should also be so trained, it is apparent that we will soon face a serious shortage of chemical personnel. Furthermore, the tabulation of the Army Ordnance includes only ordnance personnel and does not indicate the numbers needed in industry for the manufacture of primary ordnance materials. R. A. Seaton, Director of Engineering Defense Training in the U. S. Office of Education estimates that from three to six ordnance materials inspectors are needed by industry for each such inspector directly employed by the Army Ordnance. Where are these men to come from without seriously crippling our chemical engineering production and educational facilities? It places a heavy responsibility on our profession.

SO YOU'RE GOING TO EXPAND?

A few years ago the hue and cry from Washington was that most industries were over-expanded, that prices were too high because they carried too much of the cost of the excess capacity of our over-built factories. Now the shoe is on the other foot. Prices are too high because the demand is exceeding our present capacity to produce. The most ardent advocates of plant expansion are to be found, strangely enough, in the Office of Price Administration and Civilian Supply. Their views are quite unwelcome right now in certain industrial quarters, yet their underlying philosophy differs but little from the fundamental creed of chemical industry, viz.—more goods at lower prices.

OPACS has been directed to stimulate production for civilian use in such manner as will not conflict with military defense requirements. This means more complete utilization of our present capacity and employment through continuous operation, for example, or it means building new plants. Administrator Leon Henderson personally favors the latter for several reasons. In the first place, it will insure adequate supply for both defense and civilian needs. In the second place, it will tend to keep prices down by keeping production ahead of demand. The third reason is that after the present emergency, supplies of goods from greatly enlarged plants will be so abundant as to insure sharp declines in prices. That effect is desired by the New Deal economists as one means of stimulating larger consumption of materials because the unit costs presumably will be lower. This idea is not particularly new to chemical manufacturers, most of whom have long held the view that it is good business to share with the customer the benefits of improved technology.

Such advances in production technique—whether they result from building new plants or revamping and modernizing old ones, should appeal to chemical engineers and executives who are looking ahead to post-war competition. Already the agents of certain European countries are offering goods for future delivery in South America at exceedingly low prices. This may not worry us now, when many firms are too busy to manufacture for export, but there will come a time when we will need the lowest possible costs of production. It is not too soon to plan and work toward such higher efficiencies in plants and processes.

The problem of plant expansion is not nearly as simple as these fine theories might imply. There are those in industry who challenge the sincerity of the New Dealers, who really believe that the huge munitions program is leading toward eventual nationalization or socialization of many of our

enterprises. These men fear over-expansion as the first step toward governmental control.

Apart from these more or less theoretical obstacles, are, of course, some very real difficulties in these times in securing necessary construction materials and equipment. A major program of plant expansion or modernization should not be attempted until a thorough study has been made of all phases of the problem—from plant location and selection of site, through the building design and construction, to the processes and equipment layout. Elsewhere in this issue, the editors of *Chem. & Met.*, with the aid of competent contributors, have prepared an unusually comprehensive report on all these and other phases of the problem of plant expansion.

So, if you are going to expand, our best advice is to do it wisely and well. Make certain that you are building in the right place at the right time and the kind of a plant that will put you in the right position to meet the needs of tomorrow as well as those of today.

PLANNING FOR "ERSATZ"

Many substitutions of new materials for old are being required. Many more such adjustments will be made necessary by shortages, either temporary or protracted. Chemical engineers in many process industries will have to bear the burden of finding acceptable new materials to take the place of the goods rightly diverted into military uses.

Most of us have already faced this problem, at least casually. Many industries have already begun the substitution of the more abundant for the less available. The suppliers of materials are already struggling with the questions: "What about post-emergency times? Will our customers then return?"

But too few of us have clearly thought the thing through. Here is one example. There has been a severe but perhaps temporary shortage of aluminum. Much recent use of that metal has, therefore, been stopped and substitute metals or materials applied. A large number of aluminum users have shifted to copper. And now the question is, "Was that a wise shift, even as a temporary expedient?" We doubt it.

In the long run it is going to be much harder to get an abundant supply of copper for defense and civilian usage than it is to make more aluminum. Chemical engineers must remember this fact, and many other similar facts as they plan their own "ersatz" programs.

Shortages of 1942 are beginning to become visible. It will be a great mistake to forget tomorrow's problems when planning today's substitutions. Perhaps makeshift substitution today with return to normal materials next year may be the answer. Perhaps even more radical changes next year will be necessary. Generalization is futile. But a lot of hard work and far-seeing study of material supplies on the assumption of a long and serious war is the only safe answer for the individual engineer or company.

WHO CAN DECLARE WAR?

Some divisions of American industry are in a very embarrassing position. If they exercised their full possible influence they would virtually be starting a serious military conflict in the Far East. This is particularly true of the petroleum industry. Here is the way this anomalous situation develops.

Japan is dependent on imported petroleum or petroleum products. If that nation were completely cut off by refusal of American, British and Dutch interests to sell to it, there could be only one result. Japan would have to go to war actively in an effort to get control of the petroleum supplies, probably in the Netherlands Indies.

There has been some criticism of American firms for selling goods to the Japanese as an aid to their attack on China. Doubtless many sales of other goods have had nothing but a profit motive to justify them. But the petroleum industry has been subject to export control regulations for some time. At all stages it has cooperated with the State Department in restricting exports in accordance with the diplomatic policy of the government. It has not been selling to unfriendly nations at the expense of friendly ones, irrespective of official opinion.

It is difficult to say what should be done in such a matter as this. But the decision rests with the President and the State Department. The petroleum industry should not be permitted to declare war on behalf of the United States. They have no desire to do so. They are cooperating fully. They deserve compliment and support. Instead they are getting much undeserved abuse. This is too bad, but there is little to do except publish the facts and hope that the public will understand.

POLITICS AS USUAL

Most industrial executives have accepted the government's request that "business as usual" be no longer regarded as a proper guiding principle. Now comes the business executives with equal propriety asking that Washington cease regarding "politics as usual" as a fair guide.

Businessmen have a legitimate reason for making this request. The labor situation makes it clear that at least some high officials, and certain others outside of government, are refusing to forego their immediate selfish purposes in the interest of the long range public good. Perhaps the bituminous coal strike is the best example of this.

When the public generally catches on, as they soon will, then "politics as usual" will no longer be a safe slogan. It will then become "good politics" to forget politics for a while.

CHEM & MET REPORT ON

Design and Construction of Process Plants

TO PROCESS INDUSTRIES EXECUTIVES AND ENGINEERS

With plants in most parts of the chemical and process industries operating at capacity, and demands constantly on the increase as the defense effort accelerates, many companies are finding themselves faced with the need for rapid expansion of productive facilities. However, many new problems arise in this connection, since the country is moving rapidly into a war-time economy and shortages are already beginning to appear owing to military demands and labor stoppages. Managements are therefore faced with many important decisions. Is expansion actually necessary? If so, where and how? What troubles may tie up an expansion program, and how may it be possible to avoid them? What about over-expansion, what are the trends in building design, and what special precautions are called for at present? To these and other questions which must be answered, and answered in a hurry, this special report is dedicated.

CHEMICAL AND METALLURGICAL ENGINEERING

MAY, 1941

An Introduction to a Report on Problems in Plant Expansion

S U M M A R Y   A N D   C O N C L U S I O N S

Many plants throughout the chemical and process industries are operating at capacity, yet still more output is being called for. This poses the problem of whether the time is ripe for expansion, and if so, what to do about it. Shortages in materials and equipment have already appeared, conditions are changing rapidly, and past periods of over-expansion recall the dangers of over-enthusiastic building, despite the needs of the immediate future. *Chem. & Met.* has therefore attempted to assay some of the problems in this 48-page report. Although answers are not possible to many of them, their existence is worth pointing out. *Whether* to expand is a question for individual managements. To the problem of *"Where?"* perhaps the best answer may be "Decentralize." The simplest phase is *"How?"* and to that we have believed it worth while to devote the bulk of this report.

Appraising the Situation

AMERICA is in the opening phases of an industrial building program that will surpass all previous efforts, barring the improbable event of an early and favorable termination of the European War. Industrial building is as yet much below previous peak levels, but it is headed higher —vastly higher—and chemical and process industries are going to share in that expansion. Already many companies are operating at capacity, with demands rapidly increasing. Managements cannot see where the extra production can come from without extensive new facilities, yet the problems of attaining that new capacity are becoming increasingly difficult to solve, and the wisdom of adding considerably to plant facilities, except in the case of direct munitions, is being seriously questioned.

Few people doubt the desirability of sharp increase in our facilities for the manufacture of all materials needed directly in the defense program. Plant for explosives, projectiles, arms, aircraft, tanks, ships and all other materiel required for our own protection, and under the lend-lease act, must be made available to provide the quantities we must have, when they will be needed. The problem arises in the case of strictly civilian materials, and those commodities that go indirectly into military requirements, or into both civilian and military channels. Such is the case with many of the process industries, and it is in an effort to help these last that this report has been prepared.

The case for expansion in much of the process field is a good one, far better perhaps than in many other industries. For one thing, much of our foreign competition after the war will be from materials made in process plants, and efficient capacity and better products will certainly be needed in that cut-throat period. For another, chemical industries are the great developers of substitutes superior to the materials they replace, and much substitution for critical materials is going to be needed both before and after the world is again at peace. From the military standpoint, most of the products of our field are the building blocks for other industries, and therefore essential throughout the defense program, even though their ultimate destination may not be too easy to trace.

Against expansion, without the utmost urgency, there are also telling points. The spectre of over-capacity in the post-emergency is a real deterrent and not one to be passed off lightly. Equally telling is the physical difficulty of adding to facilities, for shortages of necessary materials and equipment are already making themselves felt, and will continue to do so with increasing frequency. Finally, there is the philosophy of "guns before butter." We are rapidly moving in that direction, recent assurances from Washington to the contrary, or at least in the direction of "guns first, butter later." In spite of the organization of the Office of Price Administration and Civilian Supply, which has the function, among others, of looking out for the production of normal, peace-time materials, Washington is now talking of a reduction of at least 20 percent in civilian consumption, and a deliberate policy is in the process of formation, looking toward the enforcement of civilian economizing through high taxation, and possibly forced loans for defense.

Thus the country is about to face the situation where much of the rapidly increasing purchasing power, which is following wholesale re-employment, will not be available for normal expenditures. The temptation to divert to civilian needs materials

required for quick re-arming will thus be avoided and decisions regarding possible plant expansion in some fields may be taken out of the hands of their managements through the mechanism of the priorities system. In the case of a few materials where civilian use conflicts with the military, priorities are already being applied.

This is not to say that much expansion in the process field will not be essential, and so considered in Washington. What *is* essential will be the principal question. Sometimes Washington, through the Office of Production Management, is going to be able to warn of impending shortages before they occur, and recommend appropriate action. In other cases, however, it is going to be strictly up to the industry, or to individual manufacturers, to foresee impending needs and be ready in time to avoid dislocations

If the problems of a plant expansion program at this time seem overly difficult, still there are mitigating circumstances. Against the possibility of over-expansion, there is the posility of carrying on a decentralization of industry which, if wisely done, will yield permanent dividends in better distribution of industrial effort with respect to existing populations; new markets for manufacturers; permanently higher employment; and a lasting higher standard of living.

Then, there is still another side to it. Expansion may not necessarily mean over-capacity. Only the slightest study of the growth of process industries will prove a convincing demonstration that process products, in the main, have advanced at a much greater rate than the growth of population would indicate. And modernization without a great capacity increase may be still another means of avoiding untoward effects. How this last possibility works is evident from the policies of a number of manufacturers: Amortized or partially amortized equipment is being kept in operation for the present, but is being paralleled with new equipment, with the whole capacity operated for the duration of the need. With the emergency past, the old equipment can be retired.

Still other companies are hedging against the future in the types of facilities being added. In such cases the emphasis is on buildings and equipment that can readily be adapted to other types of production if they should later prove to be extraneous for the original purpose.

Whether to expand is, of course, only a part of the picture. Where and how are perhaps even more important. Study of existing bottlenecks will often reveal that only a part of the flowsheet will need to be extended or modernized to give the desired overall capacity. Frequently, relocation of existing equipment and the utilization of the space so saved may turn the trick without the addition of new buildings. Again, duplication of some critical part of the plant will accomplish the desired end, without more than an added building or two. Prudence would seem to dictate that only when these possibilities have been exhausted should a new plant, at a new location, be considered. The less that must be added to capitalization in these uncertain times, the better, but if it *must* be added, then how and where?

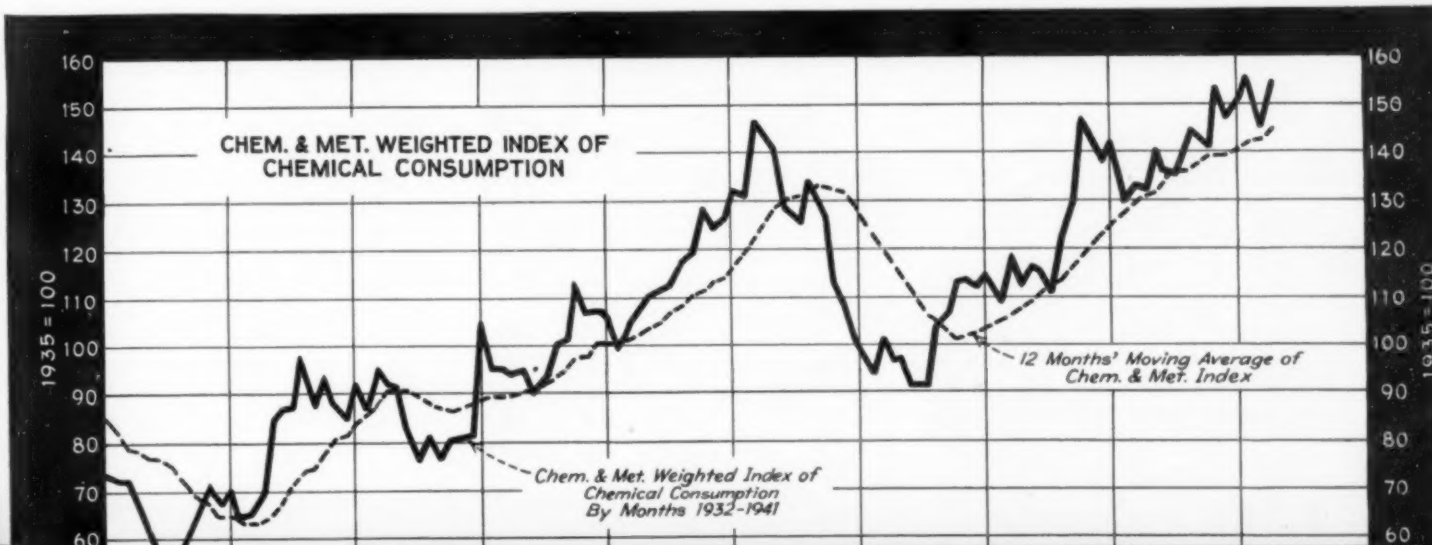
The job of a prophet is a thankless one, at best, and *Chem. & Met.* has no intention of projecting the chemical consumption curve shown below far into the future. No clairvoyance is needed, however, to see the trend, and not even the curve is needed to point to the probabilities in the face of the program before the country. Expansion is in the cards. Let it be wisely conducted!

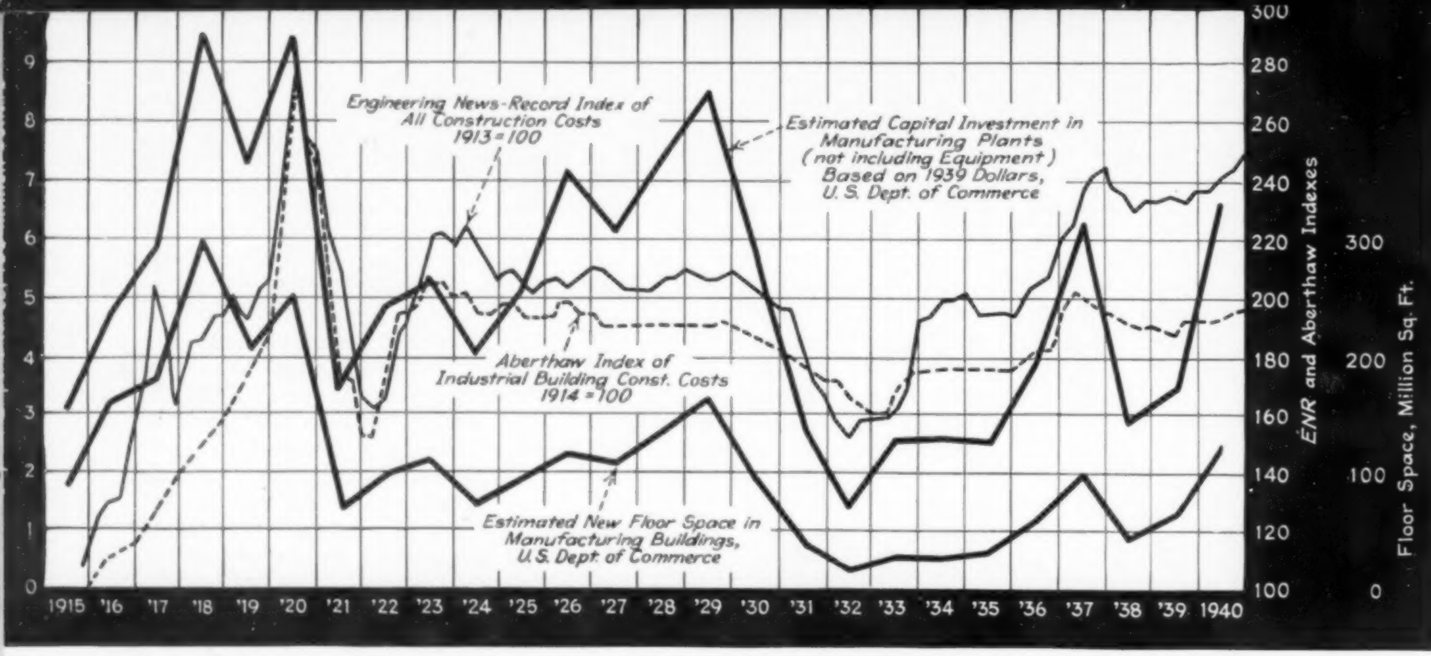
Helps and Hindrances to Expansion

WHAT has been written above has indicated that the course of any plant expansion program may not be plain sailing. What are some of the problems in more detail, and what are some of the ways they can be mitigated? Rising building costs and increasing shortages may be important factors on the debit side, while new financing methods, and paths around some of the shortages, are credits that the manufacturer can take. These matters are worthy of more extended consideration.

Unfortunately, there are too many imponderables in the situation to project building costs with any degree of accuracy. Certainly, if supply and demand are permitted to have their way, construction costs during the rearming period cannot do less than follow the pattern of the World War years, as shown by the curves on the following page, supplied by *Engineering News-Record* and the U. S. Department of Commerce. However, more likely than not, what has already happened to steel prices will happen to many, or possibly most, commodities, and perhaps to wages as well. Price ceilings will probably be set "for the duration," and supplies will be apportioned in relation to the urgency and importance of the demand, rather than by ability to bid high.

Particularly interesting to note in these curves is the tremendous industrial expansion which took place during the World War years and shortly thereafter, and the enormous rise in building costs accompanying it. This





If history is the best guide to the future, then the curves above will be of value in projecting industrial building costs and volume into the months ahead. Covering the period from 1915 to the present are two cost curves; one of factory construction value expressed in 1939 dollars; and another charting new factory floor space installed

is emphasized both by the two cost index curves and by the index for new factory construction in terms of floor area built. The trend is not quite paralleled by the capital investment index, since at various times in the period covered by the chart, different kinds of construction were being emphasized, with widely varying costs per unit of factory area. However, all these indexes present much the same picture, and one that may show what the near future holds.

WHAT ABOUT PRIORITIES?

In addition to the chance of much higher building costs, there is the even more pressing matter of materials shortages. Recently there has been set up within the Office of Production Management a priorities division which has the function of apportioning available supplies of certain materials and commodities so that defense requirements will be met first, and the remainder divided rationally among civilian uses. A list of important materials having military applications and known as the Priorities Critical List, has been set up by the Army and Navy Munitions Board, to be altered from time to time, as need arises. Articles on this list, when they enter into defense contracts, are automatically awarded priority ratings depending on importance or urgency. The same rating may apply to component parts. In the case of items not on this critical list, priority ratings are issued by the priorities division of OPM, both for military and for civilian contracts. The division may assign individual preference ratings to manufacturers for specific orders, or in the face of a group of closely allied problems, it may issue a blanket preference rating for a limited time. In addition, where a particularly difficult supply problem exists, it may resort to industry-wide priority control, as in the case of aluminum, magnesium, neoprene, nickel-containing materials, machine tools and a few other essential items. This last measure is for the purpose of closely controlling allocation of available supplies.

Manufacturers producing an item on the critical list must make deliveries of such items according to the order of their priority ratings and ahead of orders not carrying ratings. Items on the industry-wide priority list, however, can only be distributed in accordance with the quantities allowed in regulations set up by the priorities division.

In case a chemical manufacturer is having difficulty in securing a badly needed item, whether equipment, building material, or raw material, his problem may be put before the OPM. Frequently, the problem can be worked out by OPM's chemical division, in cooperation with other divisions, without resorting to a priority rating. However, should this not suffice, and should it be considered sufficiently urgent and essential (even in the case of a non-military requirement) a priority rating may be given the manufacturer to hand to his supplier.

At present the critical list contains few finished products for which civilian demand exists. However, most of the raw materials on the list are of both military and civilian interest. Except in the case of certain equipment construction materials, few building products are represented. This does not mean, however, that a chemical plant order may not be held up by reason of a priority-rated military order for the same product.

FINANCING EXPANSION

With the development of the defense program, a number of new methods for financing plant expansion have come into being. In the case of goods and materials intended strictly for military purposes, plants are being built by private contractors for the government, with money appropriated by Congress. Such plants are to be operated on a fixed fee basis by commercial concerns. Examples are the new explosives, ammunition, loading and arms plants. On the other hand, for plants manufacturing products of commercial types which conceivably will be of value in post-war civilian economy, several financing methods are available by means of which the risk can, to a greater or lesser degree, be shifted to the government.

In the first of these, known as the emergency plant facilities contract or "bankable contract," the government undertakes to reimburse the owner for the new facilities over a period of five years. The contract is assignable to a financial institution and hence can be used as collateral for the borrowing of needed funds. A plant so built belongs to the government at the end of five years, but can be bought back at an agreed depreciated price if desired.

In contrast to the private financing of the first method, in the second, the government, acting through an

RFC subsidiary, Defense Plant Corp., will finance acceptable expansion and lease the plant to the operator under terms depending on the destination of the product. After a stipulated period, usually five years, title to the plant passes to the Army or Navy, unless the operator wishes to exercise his option to purchase at an agreed depreciated price.

Most chemical plant expansion is being handled on a private financing basis, with rapid amortization. A manufacturer who can convince the War or Navy Department that his expansion is needed in the defense program, even if he does not have a government contract, can secure a "certificate of necessity" which permits him to write off the added facilities in a period of five years, thus making possible sizeable deductions from earned income for tax purposes during the five-year period. However, conservatism would suggest that the investment not be written off too rapidly, with tax rates rising.

A manufacturer using the emergency plant facilities contract can also secure five-year amortization through the certificate of necessity. In this case, however, a "certificate of government protection" must also be secured. Armed with both certificates, he can offset the reimbursement he receives for the facilities against the amortization, thus avoiding introducing the plant expansion into his income tax calculations.

Where any sort of government assistance is desired in connection with plant expansion, chemical industries can probably not do better than start with the Office of Production Management. A conference with the appropriate division and branch of OPM will result in valuable advice and, if sufficiently convincing to the agency, in assistance in securing the desired results, such as financing, certification, or a preference rating.

AVOIDING BOTTLENECKS

Undoubtedly plant expansion is going to encounter shortages of various kinds, both in materials and in certain kinds of labor. For the most part, it is too early to say what the shortages are going to be, aside from the obvious ones such as aluminum and other materials which are now under industry-wide priorities. While certain kinds of equipment are affected, materials for the buildings themselves are not yet restricted, except in a few isolated instances for which acceptable substitute materials appear to be available. Steel, lumber, concrete and glass are free of restriction as this is written (Apr. 30)*. Zinc is partially restricted, while brass and bronze are under industry-wide allocation, along with nickel and its alloys and other materials already mentioned. Whether or not presently restricted materials are later to be put in the priorities class, it must be anticipated that shortages may develop either locally or on a national scale, so that manufacturers with an expansion program ahead may find need for a reserve string for their bows.

One phase of the problem of shortages quite likely may be in transportation. It is anticipated that freight car bottlenecks may occur during the Fall transportation peaks, both this year and next. The Defense Commission is understood to hope that voluntary deferring of shipments by non-defense industries may alleviate the situation. Otherwise the voluntary basis will be abandoned and freight car service rules applied.

Still another bottleneck may be in certain sorts of skilled construction labor. Carpenters, masons and laborers will probably be fairly plentiful, once the cantonment building program is out of the way, but rivetters and welders may be hard to get in the face of tremendous expansion in shipbuilding and other metal working.

These various contingencies dictate the need for exploring the several possible paths that may lead to the same desired end of adequate housing for expanded plant facilities.

For example, should steel shapes become scarce, it is likely that reinforcing steel, at least, will still be obtainable and reinforced concrete can be employed. Vastly improved methods of wood construction have been developed since the World War, and numerous wooden factory buildings can probably be built without serious strain on the supply of either materials or labor. Assuming that corrosion resisting metals adequate for the new types of connectors can be had, greater use of wood construction may be a desirable move for the chemical industry since the wood itself is fairly maintenanceless, and cheap, quick and relatively fireproof construction results.

One factor that must be considered is the possibility that much present construction may turn out to be unusable or improperly situated after the war. It would seem, therefore, that lighter structures, or those which have a high salvage value, or can readily be taken down and relocated, or rearranged, should prove attractive in many cases. This suggests the possibility of making increased use of factory-cut and prefabricated buildings, which may also increase the efficiency of construction labor application. Another possibility is the further spread of outdoor or semi-housed types of plants. Still another is greater emphasis on lighter types of steel construction, with light inclosures of salvagable materials.

Considering the possibility of freight dislocations, another matter for study is the emphasizing of locally produced materials. Manufacture of both cement and structural clay products is widely disseminated and buildings made principally from these materials and wood may be a means of circumventing trouble.

So far as labor is concerned, both wood and masonry construction will probably not present serious difficulties. With steel construction, a shortage of rivetters can be obviated by the use of bolted connections which, incidentally, have recently been receiving favorable consideration in parts of the construction industry. No great skill is needed to operate a pneumatic wrench and bolting speeds comparable with or higher than rivetting can be achieved. A feature of bolting particularly favorable in the chemical industry is the ease with which bolted equipment supports and working platforms can be relocated.

GOING ON FROM THERE

Above we have attempted to delineate some of the trends which are appearing and point to some of the problems that may face a chemical industry expansion program in the immediate future. Many phases of these matters will be treated in greater detail in the following pages. The remainder of this report is divided into three sections: the first on plant location in the light of the present situation; the second on plant design, layout of equipment, and the problems which confront the plant's building department before even a footing can be poured; and the third on the buildings themselves. This last section, the most extensive part of the report, treats numerous subjects ranging from trends in process plant building design, to new developments in the materials and elements going into buildings.

* A possible move in the direction of priorities for other construction materials was the order announced on May 1 by OPM, placing 16 metals under buying control to prevent building up excessive inventories in the hands of users. Included are various minor metals, secondary metals, iron and steel, lead, copper, brass, bronze, etc.

Plant Location With an Eye to the Future

EDITORIAL STAFF

Particularly needed at this time of unprecedented industrial expansion is exact information relative to the location of new plants for the process industries. In the following pages the editors of *Chem. & Met.* summarize certain pertinent factors and data on the problem in light of today's needs and tomorrow's necessities.

In spite of the numerous uncertainties in today's industrial picture, chemical and process industries will find that much of the increased output demanded both directly and indirectly by the defense program, cannot be handled in existing plants with present equipment, while a considerable part, for lack of space or reasons of expediency or economics, will require new plants in new locations. It is desirable, therefore, to review here the classical principles of plant location and to determine, insofar as possible, how those principles must be modified in 1941.

Two general principles emerge from the mass of more or less unrelated factors which must be correlated in the solution of plant location questions in this war-torn and economically upset world of today. One is the question of prudent location from the standpoint of passive defense; the other the equally pertinent and even more difficult problem of location in relation to the economic welfare of the company and the country, today and in the uncertain future.

What is a prudent attitude toward plant location from the standpoint of passive defense? The most obvious principle is decentralization and location at points relatively distant from the coastlines and international boundaries of the United States. However, there is no apparent agreement among authorities, either governmental or military, as to the degree of likelihood of attack on any part of the United States. Common prudence dictates that defense plants should be well away from coasts and boundaries and should be broken down into as many units as can be justified from the standpoint of available supervision and economic production. How far should the same principle apply to non-defense plants? Nobody knows and the question is evidently one that must be answered by individual managements. All that we can offer here is the highlights of existing opinions, pro and con, with a discussion of factors that must be considered in a decision.

In the light of present knowledge of military potentials, it would appear to be impossible for any combination of powers to make a concerted and successful attack upon the United States. It is conceivable that sporadic and occasional bombing attacks might be undertaken by a future enemy. It is conceivable that this enemy might obtain bases within bombing distance of the United States; that bombing might be undertaken by carrier-based warplanes; and even that long-range bombers, based on present territories in the hands of potential enemies, might succeed in hitting an occasional objective in the United States.

However, one has but to superpose a map of the British Isles upon the United States, and find them almost lost in the Mississippi Valley, to realize what problems the tremendous area and present decentralization of United States industries poses for a potential enemy. Occasional bombing is, of course, only an irritant. Concentrated bombing, which appears to be impossible, destroys but captures no objectives. Invasion, which so far has proved to be impossible across the 20-odd miles of English Channel, looms so remote as to be unthinkable across the 2,500 miles of North Atlantic, the 1,600 miles of South Atlantic, or the many thousands of miles of Pacific.

What military hazards, then, must be considered in 1941's plant location problem? In the light of present knowledge, evidently, none are of sufficient intensity to cause any real concern. Still, great as the distances are, engineers must bear in mind that at present the United States has many thousands of miles of coastline and international boundary, now scarcely defended. Engineers, of all people, should be the last to conclude that anything is impossible, no matter how unlikely.

Therefore, we say, manufacturers must consider all possible contingencies, no matter how unlikely in the light of present knowledge, and form their own conclusions. Perhaps the best generalization on plant location in regard to military hazards is: of two locations, other things being equal, choose the one which is safer from the military standpoint. The big question-mark, of course, arises when "other things are not quite equal." Should safety from a military standpoint take the proposed plant away from markets, from transportation, from adequate or suitable labor supplies, from raw materials, then is the safer location still to be desired? The answer is anybody's guess.

Location from the standpoint of today's and tomorrow's complex and perhaps unpredictable economic problems, is another phase of the question in which, largely, anybody's guess may also be the answer. One obvious principle does, however, appear: establishment of industries in locations which will not upset present labor conditions is highly to be desired. Present need for relocation of populations does much to stall the defense program. Even more serious, its probable after-war effect, as anticipated by leading economists, will be the wholesale abandonment of plants built to meet the defense demand and the stranding of the same populations. A hopeful aspect of this problem is that it is being actively studied by the new Plant Site Committee

which has been set up within the Office of Production Management in Washington. The accumulated information and experience of this committee is available to any manufacturer faced with a plant location problem. Active study of the problem of after-war use of new plant facilities is being conducted by the committee, together with a thorough consideration of location factors in relation to the avoidance of dislocation of populations.

So far as the location of defense plants is concerned, prudent consideration of even the most remote contingencies has dictated the delineation of an area suitable for such plants, inclosed within a line drawn about 250 miles inland from coasts and borderlines. Although many of the older plants representing a part of the defense picture are outside this safety area, all recent effort except, in the case of shipbuilding, which is of course limited to coastal areas, has gone within the safety zone. Other things being equal, nondefense plants will presumably, to a large extent, be situated within this area. Many reasons other than those of defense dictate this course. Relatively untapped labor reservoirs are an important consideration. Avoidance of further concentration in older industrial areas is another. Market development of less highly developed regions as a measure of after-war adaptation is still another.

CHOICE OF AREA

Some of the special circumstances affecting plant location in 1941 have already been considered. In addition there are the classical considerations of plant location which have been thoroughly outlined in the past and to which it is difficult to add anything at the present. Conditions from point to point change with time, with shifts in population, with changes in economic conditions, with the development of new inventions, with variations in political factors, so that a location which a few years ago might have been suitable for a particular development, may no longer be satisfactory. On the other hand, classical principles may still be applied and the extensive literature of plant location still holds.

A word about this literature: much of it exists in the form of industrial surveys, conducted by chambers of commerce, cities, industrial areas, power companies and railroads. Much of it, therefore, tends to present a one-sided picture which, if accurate and well-presented, is correct as far as it goes but may be misleading in relation to other areas. In spite of this obvious limitation, however, surveys of this sort are generally the best information of timely nature to be had. One of the most extensive bibliographies of plant location information assembled up to that time was the compilation of source material by Perry and Cuno, which was published on pages 439-42 of the August 1934 issue of *Chem. & Met.* This bibliography has been brought up to date and appears on pages 121–122 of this issue.

The classical principle of plant location as stated by Holmes was to determine that location which, in consideration of all factors affecting delivered-to-customers' cost of the product to be manufactured, would afford the enterprise the greatest advantage to be obtained by virtue of location. This principle still applies except in so far as it may be modified by defense and broad economic considerations as noted above. This principle, it will be noted, states that the best location is that in which the sum of the cost of raw materials, all transportation charges and all manufacturing expenses for the product, delivered to the customer, will be at a minimum. In considering location from this standpoint, the problem may be studied first from the angle of general area and then from the more specific standpoint of the definite region and actual site.

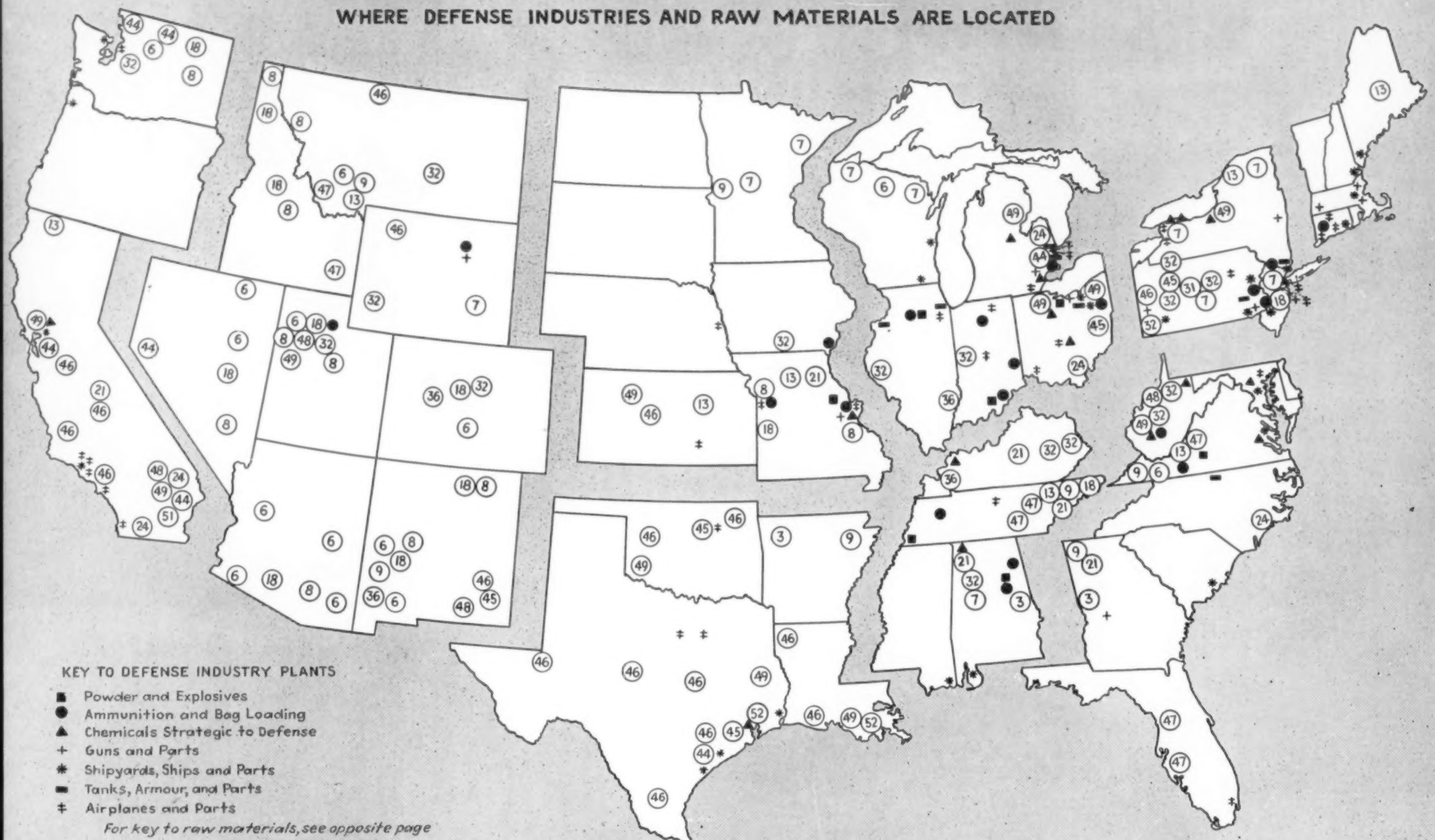
Two general classifications of factors are encountered in the solution of any location problem. First are those factors relating directly to production, including labor, raw materials, power, fuel and water supply. The second class of factors comprises those affecting distribution, including transportation facilities and rates, location of markets, and location of competitive industries. Finally, there is a third group of factors affecting both production and distribution. Included in this list are climate and legislative factors. It is not possible to segregate most of these factors on either an area or a specific location basis. To take an example, in the case of fuel, coal is produced in all but about ten states of the Union. Natural gas is produced or is available by pipeline in more than 30 states. Climate, however, and also type of water supply, are factors which may in many cases be area-determinants.

Markets also may fall in this class, for example, in the case of a plant to be established to produce chemicals used by the rubber, steel, fertilizer or soap industries, all of which are pretty well concentrated in specific areas. The same is true of many other types of consuming industries, so that this factor in itself may become an area-determinant.

In the past, labor supply has frequently been considered as an area-determining factor, but it is quite likely in the present situation, with the emphasis on decentralization and with the need for avoiding population dislocations paramount, that areas assuring large concentrations of industrially trained labor should be avoided by industries requiring a type of labor which can be trained in a reasonably short time. Otherwise, labor bottlenecks are certain to ensue. In process industries, on the average, the labor requirement per unit of output is much lower than, for example, in the metal-working industry. Furthermore, the skill required for a competent operator is usually much more readily achieved than in many other industries. The

The 200-250 mile border strip is

WHERE DEFENSE INDUSTRIES AND RAW MATERIALS ARE LOCATED



conclusion, therefore, is inescapable that an ample supply of intelligent but unskilled labor is probably a better potential for process industry consideration than an industrial area already developed and highly competitive from the labor standpoint. A corollary of this conclusion would appear to be that areas with a relatively low proportion of urban population should be those favored by most process industries. In such areas, living costs are generally low, wage rates relatively low, and populations inclined toward a high percentage of native-born. Against this, however, may be adverse conditions in fuel, power and transportation supply, with remoteness of certain types of raw materials and distance to consuming markets.

To enable a more specific consideration of individual areas of the United States, the following section of this report discusses the broad characteristics of the principal regional state groupings. A concluding section discusses those specific factors by which the area chosen may be narrowed to the community and site.

Factors in Selection of Area

New England—This traditional home of the country's earliest chemical industries holds its principal importance because of its varied industrial market. Its cotton and woolen mills, leather tanneries, and pulp and paper plants are the largest consumers of chemicals, although the metal-plating works, machine shops and other factories of Connecticut and Rhode Island add up to a sizeable chemical market.

Well-developed water power and an abundant supply of good water for process use were determining factors in attracting early chemical industries to New England and they are still important considerations in plant location. So, too, is the inherent high quality of skilled labor.

In recent years one trend, as far as the chemical industries are concerned, has been toward specialty products and packaged goods for consumption in the large metropolitan markets of New York and Boston. There will probably be a greater opportunity in the future for fabricated products, such as plastics and similar synthetics, for pharmaceuticals and medicinals, and for new industries to serve upper New England's growing importance as a year-round vacational and resort region.

Middle Atlantic States—The three states of New York, Pennsylvania and New Jersey have almost exactly a third of all the plants in the chemical process industries and in 1937 produced 28.56 percent of the total value of the national output. Nowhere else in the United States can one find such concentration of chemical manufacturing as exists in the New York, Philadelphia, Pittsburgh and Niagara Frontier areas. By virtue of the fact that "chemical industry is its own best customer," there has been a natural pyramiding of many operations as the finished products from one plant become the raw materials for another.

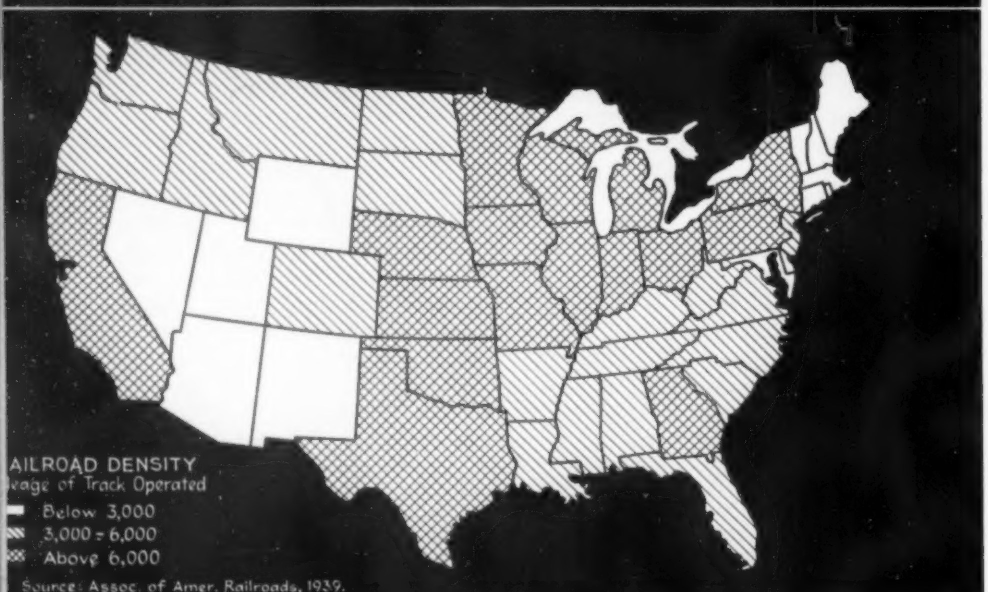
This tremendous market undoubtedly explains much of the growth of the chemical industries of the Middle Atlantic states, although their origin, in most instances, can be traced to more inherent advantages in raw materials and resources. Cheap hydroelectric power at Niagara Falls and further down (or up) the St. Law-

Chemical Raw Material Sources—Present and Potential [1]

(See Opposite Page for Location Map)

Metals [2]	
1. Arsenic	Mont., *Utah, Idaho.*
2. Antimony	Idaho, Calif., Nev., *Wash., Ariz.,* Ark.,* Ore.**
3. Bauxite	Ark., Ala., *Ga., Tenn.,* Miss.**
4. Bismuth	Calif., N.J., *Utah, Idaho.*
5. Chromium	Calif., Ore., *Mont., Wash., Wyo.,* Md.,* Penna.**
6. Copper	Ariz., Utah, Mont., Mich., *Nev., N.M., Colo., Wash.*
7. Iron Ore	Minn., Ala., Mich., Pa., *Wis., Wyo., N.J.*
8. Lead	Mo., Idaho, Utah, Okla., *Ariz., Kans., Colo.*
9. Manganese	Mont., Tenn., *Ga., Ark., Minn., N.M., Va.,* Wash.**
10. Mercury	Calif., Ore., Tex., *Nev., Ark., Ariz., Idaho,* Wash.**
11. Molybdenum	Colo., Utah, Ariz., *N.M., Wash.,* Wis., Nev.**
12. Nickel	*Conn.,* Pa.,* Calif.**
13. Pyrites	Tenn., Va., N.Y., Calif., *Kans., Ill., Mo., Ind.,* Colo.**
14. Silver	Idaho, Utah, Colo., *Ariz., Calif., Mont., Nev.*
15. Titanium	Va., *Ark., Calif.**
16. Tungsten	Nev., Calif., Colo., *Wash., Idaho, Mont.,* Ariz.**
17. Vanadium	Colo., Ariz., *Utah.*
18. Zinc	Okla., N.J., Kans., Idaho, *Mont., N.M., Utah, N.Y.*
Non-Metals [2]	
19. Asbestos	Vt., Ariz., Md., *Mont., N.C., S.C., Ga.,* Va.**
20. Asphalt	Ky., Ala., Tex., Okla., *Utah, N.M., Calif., Kans.**
21. Barite	Mo., Ga., Calif., Tenn., *Ariz., Ala., Colo., Mont.,* Tex.**
22. Bentonite	Wyo., S.D., Tex., *Calif., Ariz., N.M., Okla.,* Utah.**
23. Borates	Calif., *Nev.*
24. Bromine	N.C., Mich., *Calif., W.Va. Tex.**
25. Calcium-Mag. chloride	Mich., W.Va., *Ohio.*
26. Ball Clay	Ky., Tenn., Mo., *N.J., Calif., Ill.*
27. Fire Clay	Pa., Ohio, Mo., Ky., *Ill., Calif., N.J., Colo.*
28. Fullers Earth	Ga., Fla., Tex., *Calif., Colo., Ill., Nev., Tenn.*
29. China Clay	Ga., S.C., Pa., *N.C., Calif., Mo., Va., Ala.*
30. Misc. Clays	Calif., Colo., Pa., Ohio, *Ia., Wash., Ind., Nebr.*
31. Anthracite Coal	Pa.
32. Bituminous Coal	W.Va., Pa., Ill., Ky., *Ohio, Ind., Ala., Va., Wyo.*
33. Lignite	N.D., Tex., *Mont., S.D.*
34. Peat	N.Y., N.J., Mich., *Calif., Conn., Fla., Ia.*
35. Feldspar	S.D., Tenn., Colo., N.C., *N.H., Ariz., Va., N.J.*
36. Fluorspar	Ill., Ky., N.M., *Nev., Colo., N.H.*
37. Graphite	Nev., *N.Y., Ga.*
38. Gypsum	N.Y., Mich., Ia., Tex., *Calif., Nev., Okla., Utah.*
39. Helium	Tex., *Kans.,* Colo.**
40. Iodine	Calif., *La.**
41. Limestone & Dolomite	Mich., Ohio, Pa., N.Y., *Ill., Ohio, Ky., Mo., Tenn.*
42. Lithium	S.D., *Calif., N.C.**
43. Magnesite	Wash., Calif., *Vt.,* Tex.,* Ohio.**
44. Mg Salts	Mich., Nev., Calif., *Wash.*
45. Natural Gas	Tex., Calif., La., Okla., *Kans., N.M., W.Va., Pa.*
46. Petroleum (crude)	Tex., Calif., Okla., La., *Ill., Kans., N.M., Pa., Wyo.*
47. Phosphate Rock	Fla., Tenn., *Mont., Idaho, Va.**
48. Potash Salts	N.M., Calif., *Utah.*
49. Salt	Mich., N.Y., La., Ohio, *Kans., Calif., W.Va., Tex.*
50. Sand (glass)	N.J., N.Y., Mich., *Ill., Ohio, Pa., Va.*
51. Sod. Carbonate	Calif., *Ore.,* Wyo.**
52. Sulphur	Tex., La., *Calif.,* Utah.**
53. Talc	N.Y., Vt., N.C., *Calif., Ga., Pa., Va.*
54. Vermiculite	Wyo., Mont., *N.C., Colo.**
Agricultural Products [3]	
55. Corn	Ia., Ill., Ind., Minn., *Ohio, Nebr., Mo., Wis.*
56. Cottonseed	Tex., Miss., Ark., Ala., *Ga., La., S.C., Okla.*
57. Flaxseed	Minn., N.D., Calif., *S.D., Kans., Mont.*
58. Milk (by-prod.)	Wis., Minn., N.Y., Ia., *Ill., Pa., Tex., Mich.*
59. Oat Hulls	Ia., Minn., Ill., Wis., *Nebr., S.D., Mo., Mich.*
60. Pulpwood	Wash., Maine, Wis., *La., N.Y., Va.*
61. Soybean	Ill., Ind., Ia., *Ohio, N.C. Mo.*
62. Sugar Beets	Calif., Colo., Idaho., *Nebr., Mich., Mont.*
63. Sugar Cane	La., Fla., Miss., *Ga., Tex., Ark.*
64. Tung Oil	Miss., Fla., La., *Ga., Tex., Ala.*
65. Yellow Pine	Ga., Fla., Miss., *S.C., N.C., La.*

[1] States are listed in order of importance of value of goods produced. States in Roman type are principal producers, those in italics are producers of less importance. [2] From U. S. Bureau of Mines, 1939. [3] From U. S. Department of Agriculture, 1938. * Potential producers.



rence at Massena, laid the basis for the great electrochemical-electrometallurgical development of the early decades of this century. Salt brines underlying Syracuse proved a stable foundation for the transplanting to American soil of the far-flung Solvay soda process. Pittsburgh means more than steel, because coal and oil, limestone, glass and refractories have more than kept pace with its major industry.

Metropolitan New York is one of the largest petroleum refining centers in the world—with 12 large refineries accounting for 20 percent of the total value of all refined petroleum products. One-fourth of the paint and one-half of the varnish of the United States are produced here. Soap, dyestuffs, drugs and pharmaceuticals are leading industries that have been attracted by the great domestic market and the advantage offered by the harbor of New York for low-cost transportation of raw materials and distribution to the domestic market as well as to the export trade of the world.

South Atlantic States—Those eight states lying along the South Atlantic seaboard from West Virginia, Maryland and Delaware, south through Virginia and the Carolinas to Georgia and Florida, have few common chemical characteristics. There has long been a heavy concentration of chemical industries in the northern states of this group. Delaware has a larger proportion of chemical employees than any other state. The port of Baltimore, as the early gateway to the South, led to its premier position as a manufacturing and distribution center for fertilizers and heavy chemicals. In West Virginia, it was the famous trinity—coal, oil and natural gas—that helped to make the Charleston area one of the country's "chemical capitals".

When the chemical industries began their southward trend, during and immediately after the first World War, Virginia soon moved into a leading position. No other southern state approaches it in variety and volume of chemical production. Its minerals, especially salt, pyrites, lime and coal, have led to large industries. Its rayon production is among the largest in the country, attracted by the quality of its water, the availability of raw materials, and an adequate and efficient labor supply.

The Carolinas are just coming into their own from a chemical standpoint. Up until a few years ago, their relatively large consumption of chemicals and dyestuffs came entirely from other states. Of late, however, other advantages than the consuming market have attracted a number of important chemical enterprises. Chief among these advantages are relatively cheap power and a variety of important minerals and other chemical raw materials.

Georgia and Florida share in the production of naval stores and fertilizers and in the new pulp and

paper industries, utilizing Southern pine. Georgia's kaolin and refractory clays and Florida's phosphate deposits are essential minerals for process industries throughout the United States. They round out and emphasize the variety and essential chemical character of all of these South Atlantic states.

East South Central — Kentucky, Tennessee, Alabama and Mississippi represent a merging of the Middlewest and the Deep South. Ranking third among the coal-producing states, Kentucky's bituminous coal is her most important mineral product. Its good coking qualities will doubtless lead to further chemical utilization, such as the government's synthetic ammonia plant projected at West Henderson. More than $150,000,000 of distilled liquors is Kentucky's chief non-mineral output.

Tennessee is immediately associated chemically with T.V.A., whose comparatively cheap hydroelectric power has given impetus to electric furnace utilization of one of her chief minerals—phosphate rock. Defense production of ammonia at Muscle Shoals should prove more successful now than in World War I, for this region has made a great deal of progress in developing chemical industries.

Alabama, with Birmingham as the "Pittsburgh of the South", has its byproduct coke, cement and textile industries. Mississippi is for the most part virgin territory for chemical development. Her forest wealth has led to important production of kraft pulp and paper. Other industries utilizing agricultural raw materials will probably find an opportunity for growth in this area. Tung oil is a good example.

East North Central—A middlewesterner from Illinois, Indiana, Wisconsin, Michigan or Ohio might not recognize the Mississippi River as our arbitrary boundary between East and West. But these five states are among the most important anywhere in the national chemical economy. They accounted in 1937 for 28.27 percent of the total value of production in the process industries. Ohio's leading position stems from her rubber, soap, glass and ceramic industries. Illinois has a greater diversity of process industries to serve the metropolitan markets in Chicago and St. Louis. Petroleum refining puts Indiana next in line and its byproduct coke industry around Gary is exceedingly important. Michigan ranks high as a producer of pulp and paper and for the large chemical industries built on her salt brines. Wisconsin has an even larger pulp and paper industry and is an important producer of paint and varnish and leather products.

The varied opportunities for further chemical development in these middlewestern states as well as those in the West North Central region were summarized in last month's *Chem. & Met.* Report, Pages 95–103.

West North Central—The seven states west of the Mississippi, east of the Rockies and north of Oklahoma and Arkansas have not been important chemical producers, with the exception of Missouri and, to a lesser extent, Minnesota. Eliminating these from the group, the total value of production of their process industries is less than 2 percent of the U. S. total. There is, however, a definite movement under way to locate more of the new defense plants in this area (see April issue, page 97). A better balance between agriculture and industry in this territory could prove stimulating for both. Among the mineral resources that should prove of interest to chemical industries are the lignite and brown coal deposits of North Dakota, the gold production in South Dakota, Missouri's lead mines, Kansas petroleum, zinc and natural gas.

West South Central — Louisiana and Arkansas are seldom classed with the "Southwestern" states of Oklahoma and Texas. Yet this whole region has much in common. Petroleum is the most important mineral resource of each state. Sulphur in Texas and Louisiana, bauxite in Arkansas, zinc in Oklahoma, are other basic minerals. The westward swing of the cotton crop has made this territory a leading producer of cottonseed oil. Louisiana's sugar industry represents an investment of $200,000,000. Pulp and paper have in recent years climbed to a position of importance in both Louisiana and Texas.

The recent chemical development started with the Southern Alkali project in Corpus Christi in 1934, which was quickly followed by two similar plants in Louisiana. Sulphuric acid for the petroleum refineries and alum and paper-maker chemicals have long been made in substantial quantities in this territory. In general, there is evidence that the migration of chemical industries to the Southwest has barely begun. There are still many opportunities to utilize natural resources in the efficient production of materials needed for this market.

Mountain—The vast area of the Rockies, from Canada to the Mexican border, does not loom very large on the chemical map. In 1937 it accounted for only two-thirds of one percent of the total of the process industries of the United States. This is in spite of the fact that New Mexico leads all other states in potash production and that Montana ranks with Florida and Tennessee as a source of phosphate rock and is the chief supplier of arsenic for insecticides and glass production. Colorado has come into importance recently for tungsten as well as vanadium and uranium. Copper in Arizona, Utah and Montana is of strategic importance right now.

The great mineral resources of this mountain empire will some day be developed for chemical utilization but at present such a program is seriously handicapped by transportation costs. Only metals and minerals of comparatively high value can absorb the high freight rates necessary to reach their principal markets.

Pacific—Washington, Oregon and California are full of resources and opportunities for chemical development. Magnesite, limestone, timber and pulpwood, lignite, petroleum and natural gas, salt and bromine, borax and potash, iodine and mercury, calls the north-to-south roll of minerals of interest to chemical industry. Hydroelectric power in super-abundance is making Bonneville a second Niagara Falls while Boulder and Grand Coulee are contributing their share of cheap kilowatts for electrochemical and metallurgical uses.

Looking beyond her present pulp and paper industry, Washington projects rayon, plastics and resin plants that will some day utilize cellulose more efficiently. A greater industry, it is expected, will be built around calcium carbide as the starting point for many organic and inorganic syntheses. Fertilizers from electric furnace phosphoric acid, synthetic ammonia and western potash are on their way.

Oregon expects her future chemical development to center around Bonneville Dam on the Columbia River. Already an impressive start has been made in the electrochemical and electrometallurgical industries — aluminum, magnesium, sodium chlorate, calcium carbide. More are certain to come.

California is in many ways an empire in itself. Practically all of the chemical process industries, with the

exception of rayon and byproduct coke, are represented in her 926 plants that in 1937 produced $689,-722,000 of products—7.58 percent of the U. S. total. Petroleum refining leads in importance, followed by lime and cement, oils and greases, paints and varnishes, chemicals, ceramics, soap, pulp and paper, leather, drugs, glass, sugar, rubber, fertilizers and explosives. Some of these industries have some exportable surpluses, but in the main most of the others serve only Californian and West Coast requirements. This does not necessarily limit their growth and opportunity. These industries are young, vigorous and resourceful. They are in a rich and fertile field. Their future is as bright as California's proverbial sunshine.

DATA ON CERTAIN FACTORS INVOLVED IN CHOICE OF PLANT LOCATION

State and Geographical Area	Population [1]			Electric Power		Transportation				Industrialization				Water Supply [9]		
				Installed Public Utility Generator Capacity [3]		Railroads		Motor Trucks		As Percent of United States Total				Average P.p.m. Expressed as $CaCO_3$		
	Total, 1940	Percent change, 1930–1940	Percent Urban, 1940 [2]	Water Power, 1000 Kw.	Steam Power, 1000 Kw.	Mileage Operated [4]	Miles per Sq. Mi. State [5]	Total Registered [6]	Trucks per Sq. Mi. State [5]	Wage Earners [7]	Total Wages [7]	Value Added by Mfr. [7]	Process Industries [8]	Surface Water	Ground Water	Average for All Water
United States	131,669,275	7.2%	56.5*%	11,556	28,526	247,073	0.084	4,320,829	1.47	100.00	100.00	100.00	100.00	85	191	102
New England	8,437,290	3.3	76.1	877	2,170	6,964	0.112	270,499	4.37	12.09	11.26	9.84	4.91	......	......	......
Maine	847,226	6.2	40.5*	216	70	1,985	0.066	43,000	1.43	0.96	0.75	0.62	1.12	15	......	15
New Hampshire	491,524	5.6	57.6	236	71	1,080	0.120	25,400	2.82	0.71	0.58	0.43	0.19	11	35	19
Vermont	359,231	−0.1	34.3*	167	11	977	0.107	9,576	1.05	0.28	0.23	0.21	0.10	63	......	63
Massachusetts	4,316,721	1.6	89.4	164	1,189	1,857	0.232	106,624	13.25	5.83	5.50	4.82	2.76	19	47	21
Rhode Island	713,346	3.8	91.6	3	235	180	0.172	20,526	19.25	1.35	1.16	0.96	0.20	28	24	27
Connecticut	1,709,242	6.4	67.8	90	584	885	0.183	66,273	13.73	2.96	3.04	2.80	0.54	24	......	24
Middle Atlantic	27,539,487	4.9	76.8	1,568	8,076	22,171	0.221	717,699	7.18	28.52	29.58	29.83	19.46	......	......	......
New York	13,479,142	7.1	82.8	1,166	4,315	8,195	0.172	315,818	6.70	12.14	12.80	13.56	8.93	47	117	55
New Jersey	4,160,165	2.9	81.6	7	1,119	2,431	0.324	132,819	17.60	5.50	5.74	6.18	8.81	53	128	71
Pennsylvania	9,900,180	2.8	66.5	395	2,641	11,545	0.256	269,062	6.12	10.88	11.04	10.09	10.72	78	208	83
E. North Central	26,626,342	5.3	65.5	709	8,508	43,794	0.176	775,497	3.13	27.85	32.46	31.47	28.27	......	......	......
Ohio	6,907,612	3.9	66.8	13	2,409	8,977	0.221	184,223	4.49	7.59	8.94	8.60	10.31	125	333	160
Indiana	3,427,796	5.8	55.1	35	1,231	7,124	0.179	126,000	3.19	3.52	3.80	3.93	5.03	199	361	243
Illinois	7,897,241	3.5	73.6	52	2,547	13,231	0.234	232,888	4.16	7.56	8.25	8.91	6.83	127	345	148
Michigan	5,256,106	8.5	65.7	344	1,616	7,500	0.131	90,796	1.60	6.63	8.70	7.25	3.97	114	303	137
Wisconsin	3,137,587	6.8	53.5*	267	704	6,962	0.128	141,590	2.60	2.55	2.77	2.78	2.13	129	247	163
W. North Central	13,516,990	1.7	44.3*	539	2,412	50,782	0.100	585,392	1.15	4.85	4.72	5.52	3.67	......	......	......
Minnesota	2,792,300	8.9	49.8*	157	497	9,013	0.114	118,227	1.50	1.01	1.07	1.26	0.86	154	290	173
Iowa	2,538,268	2.7	42.7*	127	507	9,483	0.171	93,139	1.68	0.83	0.81	0.99	0.34	160	347	277
Missouri	3,784,664	4.3	51.8*	158	607	7,766	0.113	142,200	2.07	2.26	2.10	2.38	1.16	133	276	134
North Dakota	641,935	−5.7	20.6*	0	82	5,270	0.075	34,544	0.49	0.04	0.03	0.05	......	153	262	185
South Dakota	642,961	−7.2	24.6*	4	53	4,139	0.054	30,282	0.39	0.07	0.07	0.08	......	239	478	395
Nebraska	1,315,834	−4.5	39.1*	86	224	6,193	0.081	67,000	0.87	0.24	0.23	0.28	0.04	251	150	213
Kansas	1,801,028	−4.3	41.9*	7	442	8,918	0.109	100,000	1.22	0.40	0.41	0.48	1.27	187	401	274
South Atlantic	17,823,151	12.9	38.8*	2,137	2,863	25,421	0.093	489,270	1.78	12.51	9.08	9.06	7.38	......	......	......
Delaware	266,505	11.8	52.3*	0	33	298	0.152	13,500	6.92	0.26	0.24	0.22	0.20	48	85	53
Maryland	1,821,244	11.6	59.3	271	405	1,441	0.146	58,027	5.86	1.80	1.72	1.72	1.09	53	21	53
Dist. of Columbia	663,091	36.2	100.0	2	255	52	0.870	15,433	257.20	0.10	0.13	0.18	0.01	90	......	90
Virginia	2,677,773	10.6	35.3*	184	421	4,435	0.110	68,723	1.71	1.70	1.27	1.54	1.99	43	164	56
West Virginia	1,901,974	10.0	28.1	101	627	4,094	0.165	46,537	1.88	0.95	0.97	0.87	1.93	71	172	93
North Carolina	3,571,623	12.7	27.3*	709	480	4,826	0.099	81,068	1.67	3.42	2.19	2.21	0.58	25	95	28
South Carolina	1,899,804	9.3	24.5*	516	138	3,533	0.114	44,142	1.44	1.61	0.95	0.69	0.35	22	24	22
Georgia	3,123,723	7.4	34.4*	340	141	6,622	0.111	85,520	1.44	2.00	1.19	1.15	0.90	18	116	41
Florida	1,897,414	29.2	55.1*	14	364	5,353	0.092	76,320	1.30	0.67	0.42	0.48	0.33	81	173	148
E. South Central	10,778,225	9.0	29.4*	1,367	756	17,116	0.095	243,615	1.35	4.54	3.20	3.36	4.28	......	......	......
Kentucky	2,845,627	8.8	29.8	111	257	3,872	0.096	69,629	1.72	0.80	0.68	0.76	0.96	105	......	105
Tennessee	2,915,841	11.4	35.2*	512	195	3,862	0.093	64,039	1.54	1.67	1.21	1.30	1.78	82	44	65
Alabama	2,832,961	7.1	30.2*	743	255	5,302	0.103	54,947	1.07	1.48	1.01	1.00	0.85	53	50	52
Mississippi	2,183,796	8.7	19.8*	0	49	4,080	0.087	55,000	1.19	0.59	0.30	0.30	0.69	52	27	36
W. South Central	13,064,525	7.3	39.8*	153	1,752	33,089	0.083	576,267	1.44	3.33	2.63	3.37	13.28	......	......	......
Arkansas	1,949,387	5.1	22.2*	67	74	4,714	0.089	60,535	1.14	0.46	0.27	0.27	0.41	133	44	106
Louisiana	2,363,880	12.5	41.5*	0	375	4,847	0.107	84,475	1.86	0.90	0.61	0.84	2.30	65	43	62
Oklahoma	2,336,434	−2.5	37.6*	2	316	6,389	0.165	95,790	2.46	0.36	0.34	0.42	1.73	139	246	156
Texas	6,414,824	10.1	45.4*	84	987	17,139	0.065	335,467	1.28	1.61	1.41	1.84	8.84	127	143	135
Mountain	4,150,003	12.1	42.7*	1,584	505	24,786	0.029	204,936	0.24	0.88	0.89	1.12	1.32	......	......	......
Montana	559,456	4.1	37.8*	321	12	5,235	0.036	44,480	0.31	0.12	0.13	0.16	0.13	94	234	98
Idaho	524,873	17.9	33.7*	257	0.8	3,231	0.038	30,000	0.35	0.14	0.14	0.13	0.02	74	99	85
Wyoming	250,742	11.2	37.3*	49	34	2,009	0.023	18,090	0.19	0.04	0.05	0.06	0.33	106	224	154
Colorado	1,123,296	8.4	52.6*	66	211	5,120	0.049	30,636	0.30	0.30	0.31	0.37	0.71	122	......	122
New Mexico	531,818	25.6	33.2*	0.9	92	2,907	0.024	28,488	0.23	0.04	0.03	0.04	0.06	62	259	205
Arizona	499,261	14.6	34.8*	293	94	2,193	0.020	24,000	0.21	0.08	0.08	0.13	0.05	......	207	207
Utah	550,310	8.4	55.5*	92	60	2,220	0.027	21,204	0.26	0.15	0.13	0.18	0.02	170	174	171
Nevada	110,247	21.1	39.3*	504	2	1,871	0.017	8,038	0.073	0.01	0.02	0.05	......	83	187	143
Pacific	9,733,262	18.8	65.3	2,621	1,485	17,719	0.056	456,754	1.44	5.45	6.17	6.48	9.08	......	......	......
Washington	1,736,191	11.1	53.1	800	219	5,938	0.089	84,150	1.26	1.15	1.30	1.16	1.17	22	112	41
Oregon	1,089,684	14.2	48.8	279	179	3,646	0.039	62,749	0.66	0.81	0.85	0.70	0.33	10	29	13
California	6,907,387	21.7	71.0	1,543	1,088	8,135	0.052	309,855	1.98	3.49	4.02	4.62	7.58	128	150	133

[1] Bureau of Census, U. S. Dept. of Commerce, Series P-3, No. 7, Jan. 18, 1941.
[2] Largely in towns, villages, etc., having 2500 population or more.
[3] Federal Power Comm., preliminary as of Oct. 1, 1940. Includes central stations, municipal, railway and other for plants operated both by one type of prime mover and by combination of two or more types. Does not include that generated by internal combustion engines.
[4] Assoc. of Amer. Railroads. Includes miles of single track operated (miles of right-of-way) by Class I, II, and III, of steam railways, exclusive of switching and terminal companies.
[5] Calculated on basis of land area of each state.
[6] From U.S. Public Roads Adm., as of Dec. 31, 1939. Figures for New Hampshire, Ohio, Illinois, Michigan, Iowa, Delaware, Montana, and California include a relatively small number of buses.
[7] Census of Manufactures, 1939.
[8] Census of Manufactures, 1937. Process industry percentages calculated on basis of value of product.
[9] U.S. Geological Survey, Water Supply Paper No. 658.
* Denotes an increase in percent urban population, 1930-1940.

Choosing Plant Locality and Site

After selection of the area, described elsewhere in this issue, there remains the task of selecting the locality. What factors are involved and what are the best ways of reducing these, many of which are intangible, to the nearest approximation of a weighted average? Certain of the more important factors, necessarily generalized, will now be listed.

Raw Materials—Weight given to this factor is determined by the type and quantity of chemicals produced. For those which require large quantities of expensive raw materials, plants should be located, all other factors being equal, as near as possible to the source of raw materials. Investigations should include quality, quantity and reserves of raw materials; proximity to consuming plant; competitive materials; availability under unusual conditions; relative transportation cost of raw materials in, versus finished products out. If the raw material to finished product weight factor is high, special consideration should be given to relative transportation costs.

Market—Since specialty products are often sold directly, plants producing such chemicals are generally located near centers of markets. Items such as high freight costs and competitive market conditions enter into the question, as well as size and value of the market; probable future volume and value; economy of the area as a whole; and distribution and sales costs. In some instances, chemical plants have been located near a single existing market, such as the location of a plant for carbon bisulphide alongside a viscose rayon plant and for sulphuric acid at a petroleum refinery.

Wide variation in market within a relatively small area is shown by the lime industry. In 1939, about 32 percent of all lime produced in West Virginia was shipped to metallurgical mills and 5 percent to agricultural uses, while in neighboring Virginia, metallurgy took 17 percent and agriculture 18 percent of the total. The lime industry is an extreme case of the influence of localized markets, as actually metallurgy took 18 percent and agriculture over 8 percent of the total for the year.

Transportation — Transportation costs on raw materials and finished products is probably the second or third largest single cost item for products of the chemical process industries. Transportation may be by rail, water, motor truck, or by a combination of these, the deciding factors being availability and relative costs of the different services. Items under rail transportation include freight rates and competition among railroads; carload lot and less-than-carload lot rates; tram car or ferry car service; sidings, including cost of construction and maintenance; and switching charges. In general, areas near large cities offer the best rail conveniences.

Some of the problems of water transportation are those of wharves and docks; availability of barges or steamship lines; dock loading and unloading facilities or installation cost of such equipment; water rates of boat-load versus less-than-boat load lots.

Under motor transportation are included such items as proximity and condition of highways; availability and reliability of trucking services; purchase, operating and maintenance costs on truck fleets; average distance and time of haul; need for speed of delivery; and garage facilities.

As charges for transportation are large items in the cost of cement, it is interesting that during 1939 shipments of portland cement from mills in the United States by truck were 13.4 percent, by railroad 79.9 percent, by boat 2.1 percent and by unidentified methods 4.6 percent of total shipments.

Labor—Labor problems are often given considerable attention, yet for the chemical industry as a whole, wages for 1939 amounted to only 10.6 percent of the value of products. There is often a tendency to overrate importance of factors which increase labor rates and direct labor costs, and to under-rate such intangible factors as quality of labor, labor turnover, and loss from absence. For instance, if labor costs amount to 10 percent of the total cost, then an increase of 10 percent in direct labor expense (which, after all, is considerable) would increase cost of the product only 1 percent. High labor turnover alone can more than offset direct savings from cheap labor rates.

In surveying labor conditions in a locality, some of the factors to be considered are: type, quality and diversity of labor; general intelligence; availability; prevalent nationality; wage scales; ratio of skilled to unskilled; union organization; turnover rate for the community; hours of work and wages per hour as compared to other nearby industries. These factors should be considered in relationship to the type of products to be produced, yearly production rate, and normal labor costs per unit of production.

Most chemical plants pay higher rates than other industries in a locality, but if the reverse proves to be true, labor turnover will be increased and labor costs correspondingly raised. As of December 1940, chemical industry was paying an average wage rate of 81.6¢ per hr. as compared to 96.8¢ per hr. for petroleum refineries, and 68.3¢ per hr. for all industry. Although chemical labor is not heavily unionized, it might be wise for chemical manufacturers to avoid localities in which unions are particularly strong.

Water Supply—Water in chemical industry may be divided into three uses: (a) for steam or power generation; (b) for processing; (c) for cooling. It is first necessary to determine which of these factors has the most relative importance. A plant requiring large amounts of water for steam generation with relatively small amounts for processing or cooling may require a different type of water from a plant, such as a petroleum refinery, in which water is used primarily for cooling purposes. Water for boilers should be as free from impurities as possible in order to minimize purification costs and boiler troubles. Processing water should be fairly low in impurities unless the finished product is of low grade. For pharmaceutical and reagent-grade chemicals, purity of the water is of utmost importance. Well water is usually good for cooling purposes because of its uniformly low temperature in both summer and winter.

The following factors should be

Industrial Electric Service—Typical Net Monthly Bills*

	300 Kilowatts		1,000 Kilowatts	
	60,000 Kwh.	120,000 Kwh.	200,000 Kwh.	400,000 Kwh.
	Cents per Kwh.			
Akron	1.70	1.24	1.48	1.06
Buffalo	.96	.71	.93	.65
Chester, Pa	1.35	.93	1.20	.86
Houston	1.47	1.05	1.22	.85
Los Angeles	.95	.77	.87	.69
Lynn, Mass	1.68	1.60	1.63	1.57
Nashville	1.25	.83	1.04	.69
Brooklyn, N. Y	1.94	1.48	1.61	1.15
Niagara Falls	.96	.71	1.23	.62
Peoria, Ill	1.73	1.27	1.49	1.09
St. Louis	1.44	1.01	1.34	.96
Tacoma	.65	.48	.54	.42
Trenton, N. J	1.77	1.21	1.53	1.07
Youngstown	1.70	1.24	1.48	1.06

* Federal Power Commission, as of Jan. 1, 1941.

given consideration in choice of water: type available versus type for which there will be greatest demand; amount and dependability of supply; type and amount of suspended and dissolved matter; seasonal variations in quantity and quality; alternate sources of supply; temperature (for cooling purposes); cost of purchasing versus cost of purification; installation, maintenance and handling costs. Industries in which quality of water is of primary importance are those of titanium pigment, paper and rayon manufacture.

Power and Fuel—Power may be a most important factor in determining location of a chemical plant, especially for electro-chemical industries, as borne out by the fact that these plants have segregated in areas of abundant and cheap power. However, for most chemical processes, power is not one of the three or four major cost factors, the purchased electric energy for the chemical industry proper for 1937 being only 2.9 percent of the value of the products. There has been a tendency to overemphasize the influence of power costs on almost all type of chemical products. As an illustration, a plant producing synthetic phenol by the sulphonation process uses approximately 80 kwh. per ton of product phenol. Power for this at Tacoma will cost \$0.34 and at Lynn, Mass. \$1.26 per ton of phenol. And yet this maximum differential of \$0.92 per ton actually amounts to less than one-half of one percent of the value of the product. An increase in cost of benzol raw material of less than one-sixteenth of one cent per lb. would more than offset this power differential, as would also a decreased yield of 0.3 percent on benzol or a labor rate increase of 1½¢ per hr.

If electric power is a major factor, the next consideration is whether this power should be generated at the plant, purchased, or part generated and part purchased. A fair-sized chemical plant should be able to purchase electric power at about 8-10 mills per kwh. If large amounts of steam in proportion to power requirements are available, then it may be cheaper for the plant to generate its own power, and in some cases this can be done for 6-8 mills per kwh. with steam at 30–40¢ per 1,000 lb. Small plant power generation by diesel engines has also improved technique and lowered costs in recent years. Generating power can be troublesome, and if the cost is on the borderline, it may be best to purchase and let the power company have the worries.

Fuels usually available for chemical industries include coal, gas, coke, electricity and oil, of which gas and oil are most commonly used for processing since they permit greater flexibility of control. This is probably almost as important with chemical industries as cost of the fuel per unit heat value.

Taxes—Under this item belong state and county taxes. As state taxes are probably the largest single tax item, this may be an influencing factor, especially as certain states have reputations for charging exorbitant rates. The tax item for chemical industries, however, is usually a relatively small proportion of the total cost. It can usually be reduced to cost per unit of product and thus taxes for several localities or states can be compared directly. State or county taxes become significant when investment capital is relatively large and production capacity relatively small.

Climate—Although its influence cannot be denied, it is doubtful if climate alone is often a deciding factor. At times it may be of influence. For example, extremes in temperature, precipitation, humidity, snowfall and seasonal variations are to be avoided, not so much because they influence processing, but because they may affect adversely labor conditions, such as illnesses, absences from work, and general efficiency. In special cases climate can have an adverse effect on storage of materials out-of-doors.

CHOOSING THE SITE

After decision has been reached as to area and locality of the proposed plant, then the question of site comes to the foreground. Probably more errors are made at this stage than at the other two, primarily because site evaluation is on a less exact basis and competition by municipalities may confuse the issue. Misjudgment in this respect may offset advantages derived from favorable decisions on area and locality.

Transportation—This problem is of vital importance in selecting plant site. If the railroad is to be the main source of movement, a site should be selected that is located near a trunk line with a siding, or so located that a siding can be built easily and cheaply. Cities and suburban areas usually have the advantage over the country in this respect as they have a larger concentration of railroads, which insures better and quicker service, advantageous freight schedules, lower rates, quicker switching and spotting services, and generally more efficient service in all respects. The cost of switching must be considered, especially if it is not absorbed by the railroad taking the longest haul.

If water transportation is involved, then selection of site would be largely determined by such factors as location and condition of wharves and docks, loading and unloading facilities, and accommodations for barges or steamships.

Availability of through highways is a factor to be considered in motor transportation. The problem of quick

This plant has good water and rail transportation facilities

truck service or, if the fleet is company-owned, garage and maintenance service, must be considered. Suburban areas usually offer advantages of good trucking service and at the same time avoid the disadvantage of traffic problems. Motor trucks are of particular value on relatively short hauls (up to 100-150 miles), in cases where quick delivery is essential, or in cases where small and prompt deliveries are important.

Labor—Labor conditions vary considerably within areas and localities and also within communities. After the general type of labor has been determined in relation to demands of the plant, certain labor contingencies must be given consideration. These include such problems as transportation facilities to and from work; quality and quantity of housing facilities; parking lots; provisions for lunches and meals; recreational and cultural conditions. These items are influential on such labor aspects as turnover, general efficiency and absences. They are particularly im-

portant for higher types of labor and for salaried employees.

Taxes and Insurance—In general, large cities have higher property values, taxes, fire and insurance rates and bases of assessments than suburban or country sites. Existing tax rates are probably not as important as trends, and it is of considerable importance to estimate future tax rates. Factors in making determination of these items are: politicians and their influence in the community; zoning boards and their general attitude; general economic condition of the community; general status and trend of the community as a whole. Detailed investigations

Water supply and lack of congestion are of major importance

should be made through personal contact with other manufacturers in the locality. Chambers of commerce and local boards are helpful but may be unreliable insofar as they may, for civic reasons, misrepresent actual conditions. Bad streets, scarcity of schools, and general poverty usually indicate that tax rates must be increased in the future if the community is to progress. Boom towns are avoided for obvious reasons.

Atmospheric Conditions—Under special conditions, this factor should be given serious consideration. For instance, for pharmaceutical products a site should be selected which will be free from excessive air-borne contamination, such as dust, smoke and fumes from nearby factories. Air-borne cinder dust can, on windy days, contaminate the atmosphere for miles and cause considerable trouble in the manufacture of products requiring low iron content. In one case, a manufacturer of pharmaceuticals almost decided to locate a new plant very near a mixing plant for arsenate insecticides. Obviously this might have been ruinous.

Community Attitude—This factor can be of considerable importance, especially if the community is unusually receptive or unusually antagonistic toward the industry. If the attitude is antagonistic, the chemical manufacturer may find himself constantly harassed by new legislation and lawsuits, and may even be forced to close down his plant or to go to expensive lengths to reduce fumes, odors and waste products to an absolute minimum. Tax rates may also be increased abnormally, and unfavorable zoning ordinances passed. If the attitude is very favorable to the new enterprise, special inducements may be offered, such as free land, tax exemptions for a number of years, or free unoccupied buildings. These inducements should not be considered too favorably before an exact analysis of all other factors has been made. One rayon manufacturer turned down a free site worth $50,000 because other factors were unfavorable. Amortization of the $50,000 proved to be negligible in product cost as compared to that of a total investment in excess of $2,000,000.

Initial Cost—This item includes initial cost of land, improvement of existing buildings, sewerage and drainage work, waste disposal expenses, and other incidentals. Such items, although important if capital is limited, are often given undue relative weight. Depreciation on these items, especially if production capacity is large, has a small influence on unit cost. If production capacity is small or if total cost of the product is abnormally low, then the differential between interest on a low versus a high fixed capital investment may be a site-determinant.

Fumes and Waste Disposal—Odors, fumes, excessive noise, stream contamination, odors from incineration of refuse, contamination of municipal water supply or wells, etc., should be considered, especially if the site is near a center of population or an intensive farming region. The psychological and not necessarily the actual nuisance value of some of these factors may be the primary consideration. If waste disposal is a problem then it is necessary to determine if such disposal will be by stream or by settling basin and treatment plant. In the latter case, soil seepage, development of odors, and contamination of water supply enter into the picture. Of vital importance is the general directional growth of the community, especially of residential and recreational areas. Failure to evaluate properly these trends may later necessitate removal of the plant. Chemical plants as a rule are highly susceptible to public criticism for odor and fume discharges.

Safety Measures—Under this head belong such items as danger from floods and landslides, fire hazards, explosions, sanitation and accidents. Chemical plants, such as solvent recovery units, which may be highly susceptible to fire hazards should avoid congested areas, while those susceptible to explosions should make utmost plans for safety in regard to employees and to the community as a whole.

Topographic and Soil Conditions—Topographic conditions (such as land contour) may be a factor in site choice, but soil conditions are usually more important. To be considered in this respect are rock-bed conditions, type of drainage and cost of necessary foundations. Failure to give proper consideration to these factors may necessitate extensive piling or blasting operations and so increase the cost of foundations that the project has to be abandoned.

Public Conveniences—Under this are such factors as municipal fire protection, water supply, gas and electricity, quality of police protection, banking facilities, etc. Most chemical manufacturers, with the exception of specialty concerns, are not influenced considerably by such factors.

CONCLUSIONS

Choice of plant location in respect to locality as well as site should be decided only after careful and unbiased inspection of all possible influencing factors. And these, if possible, should all be reduced to a basis of their cost on the final product. However, many of the more important items are so highly intangible that their influence can only be decided by opinion. And it is probably in this respect that most errors of selection are made. Before the final decision is made, the four or five most favorable sites should be balanced against each other with all advantages and disadvantages listed in concise form with no opinions inserted. These should then be discussed by executives of the company and other responsible persons.

For an up-to-date bibliography on plant location, see pp. 121-122 of this issue.

1941 Aspects of Plant Design And Process Layout

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In this double-barreled article the author first discusses the special problems of plant design under 1941 conditions, then goes at considerable length into the development of the equipment layout, and the fitting of it to the building. An existing building usually demands compromises, but a new building can be cut to fit the process.

I. Plant Design for 1941 and the Future

Conditions favoring the selection of a site for a new plant remain largely the same in 1941 as they were before the emergency program for national defense was formulated. These include a plentiful supply of raw materials at reasonable cost; a satisfactory market within economical transportation radius; ample supplies of the right kind of labor, fuel and power at satisfactory costs; and other factors that enter the picture, each of an importance varying with the type of industry under consideration.

The spirit which apparently permeated the planning some of the defense plants, that is, "get something going," should not be allowed to control the design and construction of privately owned plants, which must be pointed at peace-time operation. Today, even more careful studies than usual should be made of the details of the process under consideration before making binding decisions. Particular thought must be given to the conditions that will probably exist during the first years after peace is declared.

Orderly and economic development of a process requires more time than most directors of operations are willing to allow for it. It has been proven time and again that feverish activity in an effort to speed up development results in much waste motion, which usually can be avoided if time is taken to allow the results obtained in one step to "ripen" before proceeding with the next. Apparently satisfactory results, obtained readily, should be viewed with suspicion until they are definitely proven after a large number of repeated runs of varying size.

There are "bugs" in every new process which must be eliminated so far as humanly possible before translation into large scale operation. At every step one must question the apparently simple engineering problem of "blowing up" the details of the pilot plant to full sized equipment. Furthermore, the fact that a given operation has always been performed in a certain way should be good cause to investigate other ways—for the results are apt to be surprising.

It often happens that research in apparently unrelated fields has already brought to light information with considerable bearing on the problem at hand. It is easy to miss such information when one's endeavors are confined to a single field of investigation. The same applies to the synthesis of the many pieces of effort required to produce an orderly engineering project. And the outside viewpoint—not too close to the trees to see the forest—can ask some penetrating questions which should be provocative of stimulating thought.

It may be found that details of operations can be simplified when maximum production is paramount, as it is today, without material detriment to the quality of the product. This might come about, for instance, through a careful study of when and where to take the least number of test samples, and still give a product of the quality desired. Not only could routine laboratory work be reduced, but also unnecessary openings and connections on the equipment could be eliminated.

Or again, a more extensive use of automatic or even semi-automatic controls might lead to simplification, an end which deserves particular attention on account of the scarcity and high cost of the right kind of labor. Possible improvement in uniformity of the product at the same or even at lower cost may follow. A study of the opportunities in more extensive use of materials handling equipment is a similar idea.

Labor requirements in most chemical plants are small when compared to many other industries. Those of the supervisory force are preferably men with some training in chemistry and chemical engineering. It has been found that men so equipped are better fitted for the job, even though it may be necessary to pay them more. However, that part of the work requiring semi-skilled labor can usually be learned by any reasonably intelligent man in a short time. The use of automatic and semi-automatic controls can serve not only as a check on what he does but also to relieve him of some of the manual work of operation. Thus his job becomes chiefly one of checking up to see that all goes as it should.

Those concerns not involved in national defense work should take care in planning increases to plant facilities at this time, to construct only those parts of the whole plan for the future that are vitally needed now. This is because, with the present rush to build plants for national defense, not only are construction costs higher than in normal times, but construction materials for both buildings and equipment are difficult to obtain.

Assuming that it will be several years, at least, before all nations are

again at peace, it is evident that after the present defense plant construction rush, the big problem for these plants will be one of operation. Consequently, materials of construction may not then be so dear and it may be possible for concerns engaged primarily in the production of materials for everyday consumption to carry out modernization or expansion programs at more reasonable cost.

Several of the factories now being built for producing war materials will be equipped with air conditioning. In addition to this feature, many will also be provided with control of such working conditions as light, sound and even vibration. The rapidly spreading use of fluorescent lighting is an important factor since this makes possible glareless and shadowless artificial daylight at all times and eliminates possible variation, chargeable to poor lighting, in the work done during the several shifts. Since such buildings have a minimum of windows and similar openings, they fit in well with any military scheme for blackouts.

Concerns manufacturing pharmaceuticals and other fine chemicals have already adopted this type of construction advantageously. Quite possibly a modified form may be suitable for those modern plants that must have windows for one reason or another. Controlled conditions, especially where there are considerable numbers of workers involved, should be good business, not only in process improvements, but also in gains in employee efficiency and morale.

For many operations that are largely mechanical in nature, instead of chemical, it can usually be shown that substantial savings in floor space can be made with the windowless type of construction, with consequent reduction in plant investment. Control of lighting, ventilation, temperature, noise, and other conditions, permits an efficient layout of the several kinds of manufacturing equipment, in minimum space and all under one roof, since heat- and fume-producing equipments can be put in their logical places in the flow line and provided for according to their individual peculiarities. This applies to both single- and multi-story buildings.

In any plant layout, the cost of buildings is an item that must be kept as low as possible, consistent with requirements. There are, however, exceptions in what might be termed the "promotional" class. Sometimes it is considered worth while to dress a plant up and make it into a show place, charging the difference to advertising. This practice would seem to be justifiable only when the sales problem can be simplified in this way, as the case of a consumer-product plant, where the public is admitted.

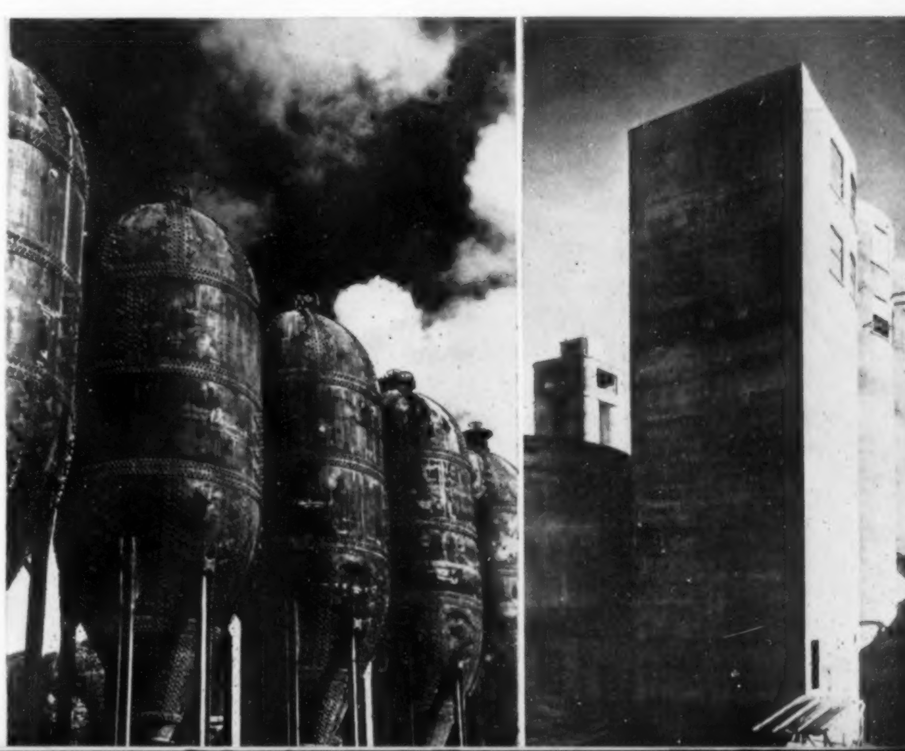
II. Equipment Layout Phase of Plant Design

Facilities required for a process consist essentially of places and equipment for the storage of the various materials used and produced, for carrying on the several operations, and for moving the materials to and from the processing and storage places. Their design is predicated on the assumption that the usual services found in an existing establishment will be available, including steam and electric power, water, fuel, sewers and waste disposal means, locker and wash rooms, maintenance shops, fire and police protection, communications, and so on. A layout involving an entirely new site would require essentially all of these facilities, the design of which is a job of considerable magnitude in itself. However, if the process under consideration is an addition to an existing plant, it will be necessary only to make a study of present service facilities to ascertain just what increases are needed to take care of the new process.

In order to reduce to a minimum the lengths of haulage between the places of storage and of processing, it is highly desirable to locate storage buildings, tanks, silos and materials piles as near as possible to the several points of use in the production line. This scheme has the principal disadvantage that it may spread the storage area over considerable ground. However, when it is possible to arrange the processing facilities in the shape of a "U," the several storage areas may be consolidated into one, to serve for raw, intermediate, and finished materials, and thus simplify the problem of storekeeping.

The housing of a given process depends, in part, on other things than the specific requirements of the process itself. The treatment will probably be different, when a new building is to be constructed, than when an existing building is to be adapted. If a new building is planned, it must first be decided whether it should be designed to house only the process under consideration, or whether it must be arranged to permit future expansion, or to meet the needs of several other processes which will probably not be altogether similar. But when an existing building is to be used, more or less "as is," then

No better example of "building the plant around the process" can be found than these tw views taken in the Everett, Wash., mill of the Pulp Div. of Weyerhaeuser Timber Co. Fo ease in assembly of the huge plates, the six 52 x 18 ft. digesters, shown at the left, wer erected outdoors, after which the concrete inclosure was built around them



the arrangement must be adapted to the structure, on a "give and take" basis. An important consideration, then, is the amount of alteration that will be permissible from the points of view of first cost and of inconvenience to existing operations.

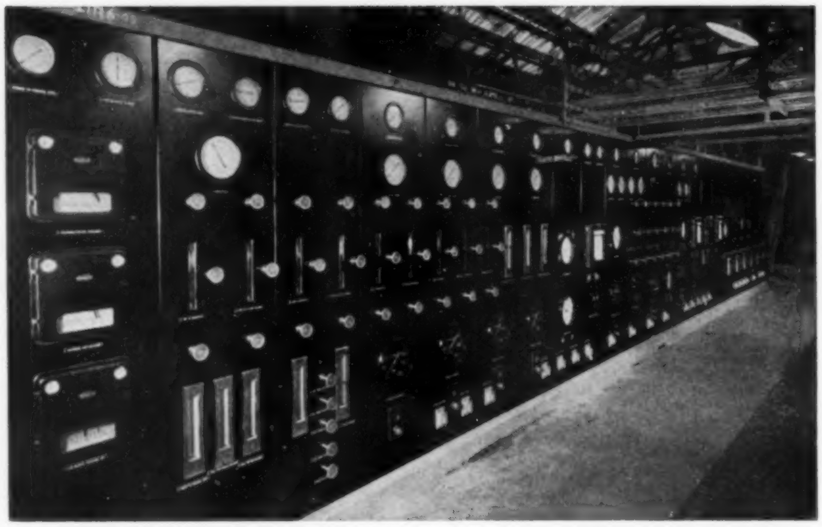
THE "GUIDING PRINCIPLES"

In planning a layout, whether for an old building or a new one, a study should be made of the possibilities for reasonable growth by ascertaining the directions in which growth is most likely. There should be a definite plan for the layout of the plant, one that will permit future changes of the layout to accommodate the growing needs of the several operations to be housed. A set of guiding principles for this layout should be drafted to enable the establishment of an ideal, no matter what the actual conditions encountered turn out to be. The determination of just what these guiding principles are for any specific problem is a matter of fundamental importance. All phases of the problem for the present, as well as the possibilities for the future, should be included in order that nothing essential may be overlooked. Such principles will, of course, be only an ideal, but they will be something to aim at.

For a specific problem let us assume that the guiding principles agreed upon are as follows:

1. Simplification of equipment sizes and materials of construction, and the use of standard designs instead of special designs. These are cheaper in first cost, and cost less to maintain.
2. Grouping of like operations so that one group of operators can tend to all equipment of the same kind.
3. Interchangeability of use of like equipment so as to provide a maximum of flexibility.
4. Type of equipment and its arrangement to be such as to permit any part or practically all of it to be repiped in suitable fashion for use on other processes of a similar nature, without need for the re-location of any of the major pieces.
5. Use of automatic and semi-automatic controls to be as extensive as an economic study shows possible (and a little farther, as well). This also applies to the use of materials handling equipment.
6. Since the proposed operations are non-hazardous and non-toxic, no special ventilation will be required, other than that necessary for good working conditions.

In making a layout, ample space should be assigned to each piece of equipment. Accessibility is an important factor and too often it is not given the attention that the maintenance man thinks it should have.



Instruments, both for indication and for control, not only check the performance of the operator but simplify his job and insure quality of the product. This instrument panel in Commercial Solvent's new nitro-paraffin plant at Peoria, Ill., tells an interesting story of automatic operation

Generally when he gets a chance to look at the set-up, it is too late to do anything about it.

Unless a process is well seasoned, it is not always possible to predict just how its various units may have to be changed in order to be in harmony with each other. This is especially true if the process is being developed from pilot-plant-scale operation, as usually carried out, with equipment not specially designed for the process. It is well known that in chemical manufacturing, processes may be adopted which appear to be sound after a reasonable amount of investigation in the pilot-plant stage, yet frequently require minor or even major changes before all parts are properly operating together.

It follows that it is likely to be extremely poor economy to fit the equipment layout too closely into a building. A slightly larger building than appears necessary will cost little more than one which will just fit. The extra cost will indeed be small in comparison with the penalties that will be extracted if, in order to iron out the kinks, the building must be added to.

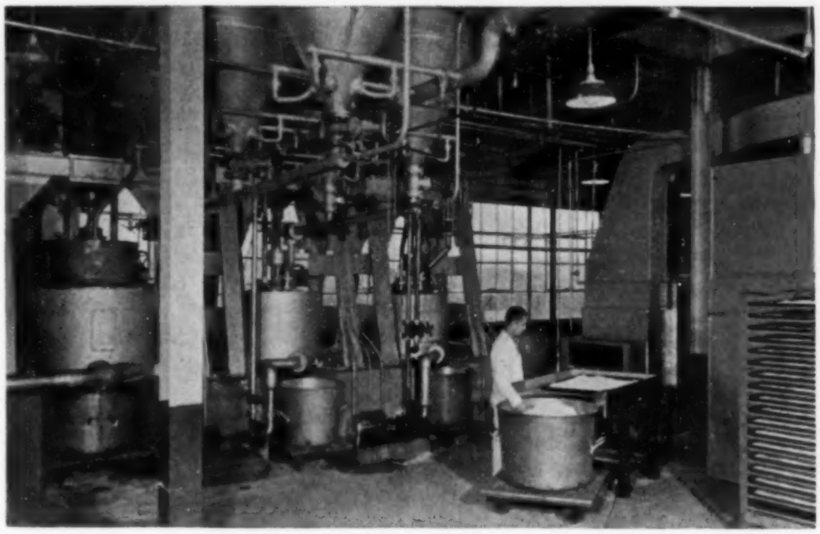
In establishing a method for making plant layouts, it is helpful to apply the scheme of using a series of diagrams, each of which represents a unit operation, and upon these to plan the details. A map of the site showing the relative elevations of the several parts is essential in order that best advantage may be taken of elevation differences. So, with the "guiding principles" before us, we will proceed.

PROBLEM IN LAYOUT

The operations that constitute our process are essentially a series of unit operations that may be carried on simultaneously. These include reaction, filtration, evaporation, crystallization, separation, drying, and others. Since these operations are repeated several times in the flow of materials, it should be possible to arrange the necessary equipment into groups of the same kinds. This sort of layout will make possible a division of operating labor so that one or two operators can be detailed to tend all equipment of a like nature.

Thus, the reaction kettles will be placed side by side on a mezzanine, at right angles to the general flow, with their scale tanks elevated enough above them to permit gravity flow into the kettles. Operating controls will be located on this mezzanine. The process under consideration requires the addition of a filter aid as the last step in the reaction kettle and then the immediate filtration of the mixture. Under these conditions, the kettle can serve as a filter-press feed tank.

However, sometimes it may be preferable to have the flow arranged so that a feed tank, of a design somewhat less expensive than that of the kettle, can be utilized to receive the contents of the kettle at the end of the reaction. With such an arrangement, the filter aid will be added in the feed tank, and the kettle will be placed above the latter for gravity discharge. If, in order to conserve vertical space, they were



Despite the attractions of single-story structures for process plants, the prospect of putting gravity to work through multi-story construction should not be ignored in many types of process. Commercial Solvents has made good use of gravity in the new nitro-paraffin plant at Peoria, Ill.

placed side by side, it would be necessary to discharge the kettle by blowing with an inert gas, by its own pressure, or by pumping.

The closed type filter press and its pump will be located on the ground floor, the press cake to be freed of liquor by blowing with an inert gas. Hence the filtrate and the wash water tanks should be elevated to the mezzanine above, where control samples will be taken. The other pieces of equipment, including the evaporator, crystallizer, centrifugals or filters, dryer and packing equipment for the finished product will be arranged in a more or less similar manner.

Some of the raw materials to be used in the proposed process are liquids and some are solids. Those liquid raw materials used in large volume will be stored in tanks located outside the building, adjacent to the railroad siding since they are received in tank-car lots. Each tank or group of tanks containing one kind of material is to be connected to a motor-driven pump and the flow of material to the scale tanks on the operating floor is to be controlled by "start-and-stop" motor-control buttons located near the scale tanks. This will enable the operator to fill his scale tank from storage as needed. Those liquid raw materials received in drums are to be stored either indoors, or out in the open (with or without a shed over them), depending on the physical properties of the materials. Drums will be moved to point of use in a manner similar to that used for solid raw materials, as mentioned below.

The solid raw materials are to be received in barrels and stored in the storehouse, a few barrels at a time being transported by platform-type industrial truck to a specially provided area adjacent to the point of use. Platform scales are to be provided for measuring out the required amount for a batch.

Solid and liquid intermediates, if not too great in volume, will be stored in the operations buildings pending their further use in the process. Their entrance into the processing equipment will be accomplished in ways similar to those used for the raw materials. However, any intermediates which are to be sold as such will be stored in suitable places elsewhere.

VERTICAL ARRANGEMENT

The relative levels of the several pieces of equipment and their accessories determine their placement. While gravity flow is usually preferable, it is not altogether necessary because liquids can be transported by blowing or by pumping, and solids can be moved by mechanical means. Gravity flow may be said to cost nothing to operate, whereas the various mechanical means of transportation involve the first cost of the necessary equipment, the cost of operation and of maintenance. However, gravity flow usually means a multi-story layout, whereas the factors favoring a single-story plant may largely, if not entirely, compensate for the cost of mechanical transportation.

Let us assume that there are available buildings that might be suitable for the process. Our problem now becomes one of applying the schematic materials-flow diagrams to these buildings and ascertaining: (1) what changes in equipment placement will be necessary; (2) what additional transportation facilities will be required; (3) the cost of the equipment; (4) what the alterations and additions to the buildings will cost; and (5) what the overall manufacturing cost per unit of product will be. While this is being worked out, it will also be necessary, in order to make a comparison, to ascertain a similar cost per unit of product based on the construction of new facilities to suit the process.

The use of existing buildings means, almost without exception, a compromise in layout, and usually additional labor to operate. Perhaps the only compensation for the use of an existing building lies in the fact that its partially amortized value may be low enough to permit making a reasonable number of alterations and thus keep operating costs within profitable limits. Indeed, if a building is available which has any prospect at all of being made suitable, much sharpening of the pencil will be needed before the "powers that be" can be converted to authorizing the construction of a new manufacturing building.

It goes almost without saying that a study should be made of the mutual compatibilities between operations in an existing plant, and those of the new process. This is true whether existing buildings are used, or new ones. For example, a process producing light-colored materials, especially if they are to be sold on color specifications, should not be placed adjacent to one producing dust, waste gases or colored fly-ash, particularly if these materials had strong tinctorial properties. An exception, of course, is when the new process is to be housed in one of the modern, completely air-conditioned buildings.

Therefore, a study of prevailing winds, especially of those in summer, can be a matter of considerable importance in the choice of a suitable site and the placement of the buildings thereon. The layout of proposed new facilities on a plot adjacent to an existing plant involves a study of all existing buildings in the vicinity and of the operations housed therein.

CHOICE OF BUILDING TYPE

If a new building is to be constructed for a certain operation, a choice must be made between a verti-

cal arrangement of the equipment, a horizontal one, or a combination of the two. This latter is the usual case. Assuming that a multi-story building is to be constructed for reasons of equipment arrangement, and not on account of cost of land, the question then arises as to whether it is to have solid floors extending from wall to wall, or whether they are to be of subway grating, or in the form of mezzanines extending part way from wall to wall with walkways between the different parts of each floor. This latter type has many advantages when used with equipment that requires several levels of platform for operating purposes.

MEZZANINE CHARACTERISTICS

A building having mezzanine floors requires a well-engineered installation of heating. It is more expensive to heat, but it is cooler in summer and its overall cost is appreciably less than that of a solid-floor building. It is a more satisfactory building from an operating point of view in that the operators can move around in it more quickly and can keep in communication with each other more easily. Usually it requires one or two less men, and it is of such internal construction that changes in or additions to the equipment can be made at lower cost than with solid floors.

As for lighting, it has been established that the best possible type should be installed at all control points. The new fluorescent lights are about all that could be desired. For many uses the white lamps are preferable to the "daylight" type. If a process is to be operated on a two- or three-shift basis, it has been found that good artificial lighting at the control points at all times is preferable to daylight part of the time and artificial light for the balance.

SERVICE FACILITIES

Service facilities needed for the process under consideration consist of power in the form of steam, electricity, and compressed air; treated water for process work; raw water for cooling purposes; process and sanitary waste disposal; maintenance facilities; police and fire protection; as well as locker rooms and toilets. Also required is intra-plant transportation and communications. Unless the operations proposed are to be a considerable addition to those of the existing plant, present service facilities such as maintenance, communications, police and fire protection, transportation, and waste disposal can be extended without much difficulty to include the new plant area.

In meeting the additional requirements of steam, electricity, sewers, air, treated and raw water, however, it may be necessary to make increases in the existing facilities such as will be much in excess of the quantities desired. For example, if the present steam demands, including peak loads, should be just about all the present boiler installation can handle, it is logical to add, not another boiler of just the proper size to handle the additional load, but one that at least matches the others now in use. Perhaps the new one will have a capacity two or three times the desired additional load and its installation may demand an increase in fuel handling facilities out of all proportion to the additional steam load demanded.

The same idea applies to the other requirements, as well and the total cost of construction of the facilities for the new process should be presented in such a manner as to separate the cost of the operating and storage facilities from that for the additional service facilities required.

WASTE DISPOSAL

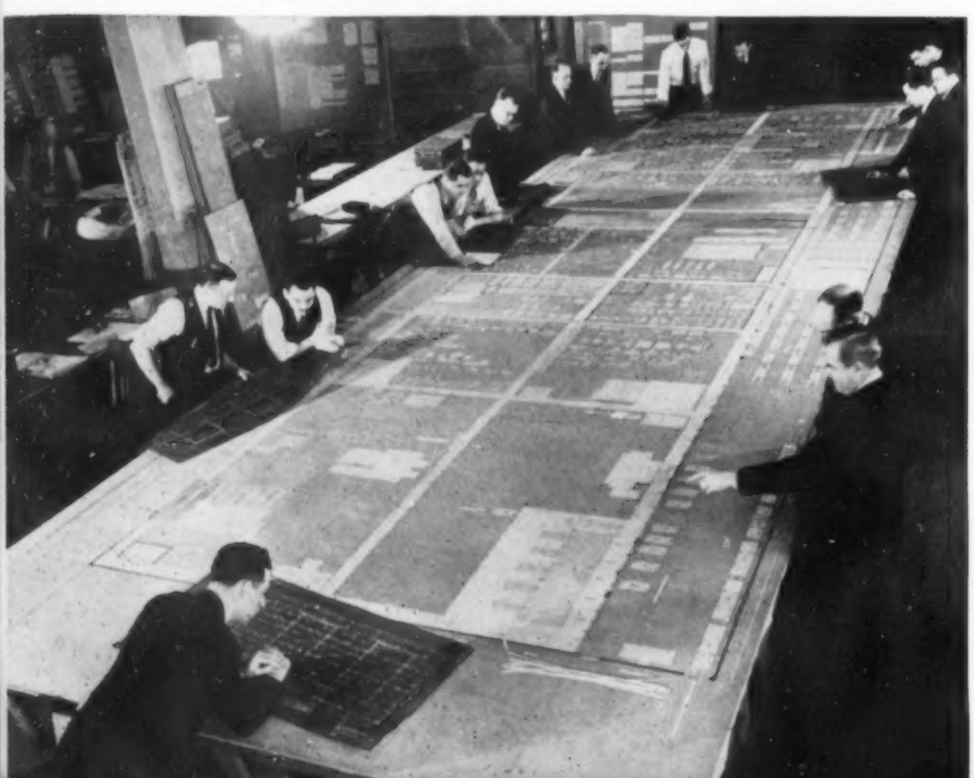
Disposal of industrial wastes is a matter often requiring considerable study and ingenuity, as well as good, sound engineering. Wastes may be gaseous, liquid or solid. Gaseous wastes, if malodorous, are usually combustible and can be disposed of by burning, but even this may not solve the problem entirely if, for example, sulphur dioxide is produced.

Liquid wastes generally require treatment so as to precipitate most of the objectionable matter, or to make possible the skimming off of tars, oils, and other substances that rise to the surface. Often the effluent must be neutralized and oxygenated if it is to be turned into streams, so as to avoid the killing of fish. Combustible matter, either liquid or solid, is best disposed of by burning, care being taken to insure proper disposal of any objectionable gases that may be formed.

Solid wastes, such as sludges and filter-press cakes, can be transported "as is" to the dump, or after dilution with water can be pumped to a sludge pond. However, the leaching of solids by weathering, when so deposited, is a part of the problem since the solution usually will find its way into a nearby brook.

The foregoing has been presented to bring out the many factors entering into the planning of a plant layout. It is impossible to go beyond general rules, however, and every project must be treated as an individual problem, having its own peculiarities to be solved.

Few engineering offices in the process industries will ever be faced with a layout problem as complex as the one being solved here in the design of the Chrysler plant for 25-ton tanks. Nevertheless the idea is a good one and the automobile industry's layout board could well be adopted in other industries



How to Turn a Cornfield Into a Factory

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After a plant site has been chosen, there are many problems that have to be solved before it is possible to go ahead with construction. Providing rail and highway connections, deciding on the location on the site, arranging for water supply, and sewage and waste disposal are things that are first on the engineer's list of "musts."

PLANT DESIGN encompasses a great many problems outside those of the process, the location, the layout of equipment, and the construction of the buildings. With the trend toward decentralization, more and more companies are literally "moving to the country" to secure room for expansion, low land values and taxes, and new supplies of labor. Turning any site into the location of a new factory can provide a good many puzzling situations. Even more complex is likely to be the problem of handling a rural site. However, once the right cornfield has been decided upon, wonders can usually be accomplished within the space of a few months.

When the search for a suitable site has narrowed down to the best two or three, it is time to open preliminary discussions with groups that are able to supply the most reliable information on all local conditions affecting the proposed plant. Railroads, power companies, local representatives of coal mines and natural gas producers, tax and highway authorities, and boards of health, are among these. Their assistance will be essential in securing the information needed in arriving at the final choice of the most suitable of the sites under consideration.

Collecting Information—With the site selected all essential information should be gathered at the earliest possible moment. This includes careful surveys to determine the boundary lines and the topography of the site, together with the exact location of all physical features, such as rivers, highways and railroad tracks, which may affect the layout.

Usually both open test pits and borings will be required to determine the character of the underlying soil and its suitability for foundations. In case of doubt it is always best to go deeper than may at first appear necessary. Often, layers of what first appear to be solid gravel will be found underlaid with quicksand, while in other cases, what is apparently soft rock will be perhaps only a foot thick, with layers of soft clay beneath.

Flood Levels—In about 90 percent of all new plants located on virgin sites, the location will be in a river valley, since most wide stretches of level ground suitable for building large plants are so situated, while most trunk-line highways and railroads tend to follow river valleys. There are exceptions, of course, but not many.

In connection with any new site, fullest information should be gathered on all previous flood levels, but even these must not be taken as safe levels. It can always rain harder and longer at any given spot than it ever did before. The height of the Merrimac River at Lawrence, Mass., in the 1936 flood, exceeded the previous 90-year record by 10 ft. On August 30, 1940, a flood at the plant of the American Enka Corp., near Asheville, N. C., was considerably above any previously known flood for over 100 years. The rainfall in the mountain area immediately above the plant was close to 12 in. in 24 hours. Hence, if there is any latitude whatever as to the height of setting the plant it is better to be safe than sorry.

Locating the Plant on the Ground—After completing the surveys and topographical maps, it is possible to study fitting the plant on to the ground. It is assumed that by this time all physical features of the general plant layout will have been studied and that a tentative layout has been reached, fixing the desired spacing and relative position of the different plant buildings and other features.

Many factors enter into the decision of how to fit the buildings on to the ground in the best manner. These include the provision of adequate space for such further extension as seems reasonably probable, the establishing of floor grades for the various buildings, the provision of a layout properly served by transportation connections, the orientation of the buildings with respect to sunlight and ventilation, and the appearance of the plant from important highways and railroads.

Railroad and Highway Connections—Practically all plants will require good railroad connections. While not absolutely necessary, many plants have succeeded in obtaining railroad connections from two separate lines.

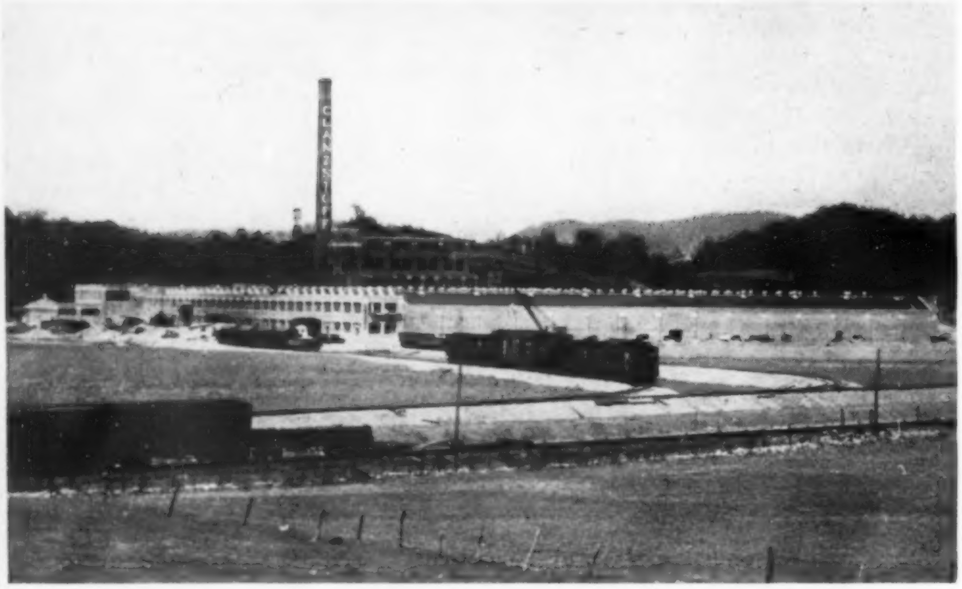
Railroad sidings should be laid out carefully before the building locations have been finally fixed. All curves should be kept to a generous radius, with minimum grades for easy switching. If there are to be sidings in the yard on which cars will have to stand for long periods for loading or unloading, bypass tracks should be provided so that other switching need not be delayed.

In general, floors of all buildings where material is handled in or out should be set at car floor level, a principle which also holds good for buildings receiving or shipping large quantities of material by truck. Covered loading platforms will be found a great convenience and for most plants are well worth their cost. Adequate paved roadways should be provided connecting all buildings in the yard with main highways.

Water Supply—Most plants in the chemical industry require an adequate supply of clean, soft water, and many such plants also need ample cooling water, which can be had at a considerable saving if obtainable directly out of the ground. Most plants taking water from rivers or surface streams will find it necessary to install pumping and filter plants.

Sanitary Sewers—Plants built on new sites, away from established cities, will usually have to provide their own treatment for sanitary sewage before discharge to a stream. Modern methods of simple and economical treatment are available, which can readily be made satisfactory to the various health boards having jurisdiction.

Factory Wastes—In the past many



When North American Rayon Corp. decided some time ago to locate at Elizabethton, Tenn., near the plant of American Bemberg Corp. (in the background, upper view), problems such as those outlined here were faced before the ground was broken. Two stages in the metamorphosis from farm land to industrial plant are shown here, the first on Oct. 15 and the second the following May 1

In most states today will be found a state labor department. Many states have their own separate codes of practice dealing with factory construction and operation. The minimum requirements of such codes will usually be found to deal with the more elementary items of exits and fire escapes, ventilation, toilets, locker and wash room facilities. In some of the more highly developed industrial states these codes will be found to cover a multitude of subjects dealing with the safety of plant employees. In general, these boards are headed by conscientious, hard-working and capable officials and early consultation with them at the beginning of a project will be found advantageous.

If the site of the plant is within the corporate limits of any city or town, it will be found that there will usually be several boards or departments having jurisdiction over different features of the plant layout and equipment and that most of these will require the submission of plans, the filing of application blanks, plus payment of a filing fee, and finally the issuing of official permits before work can be started.

industrial plants set up adjoining rivers or streams have simply turned their wastes loose into the stream, without giving much thought to its effect on animal life and on other users. Now that there is a growing consciousness of the evils of stream pollution and an increasing amount of legislation on the subject, new plants having waste products to discharge will do well to investigate the subject thoroughly. It is a fair statement to say that almost any new plant having offensive wastes will, as a very minimum, have to set up a satisfactory sedimentation treatment to remove the larger part of the settleable material. Some plants will have to follow this by filtration for further removal of objectionable wastes.

Fire Protection—In considering a new plant set-up the question of fire protection must be given study and most isolated plants will have to provide their own facilities, entirely independent of assistance from city or town fire departments.

Submission of plans for Approval—When the plans have been developed to a point where they show most of the important information on layout and character of the plant, the time has come to submit them for discussion and approval to various authorities having jurisdiction over various plant features. Among these are:

The fire insurance group having jurisdiction which should be consulted with regard to the type and extent of protection proposed for the plant. The larger insurance groups maintain adequate and competent engineering departments to render such service, and the fullest use should be made of these facilities. Decisions made at this time influence the insurance rates which will be set up for the plant and which will be a continuing source of expense thereafter.

Other Features—Layout of a modern industrial plant on a new site requires that provision be made for driveways, sidewalks, yard paving, loading platforms, fences around the property, parking space for automobiles, coal storage space, space for oil tanks, chemical storage, etc.

Building the Plant—Following the completion of working drawings and specifications for the various parts of the work and the securing of bids, contracts can be placed and actual construction and installation work can be pushed through to an early completion. If the project is one where the utmost speed is required, the structural steel drawings should be completed first and the steel purchased. Then the foundations can be installed while steel is being fabricated so that it can be erected immediately on arrival. Similarly, items of equipment requiring the longest time for delivery should be ordered first.

A definite progress schedule should be made up at the beginning of the operation, based on definite guarantees of deliveries of structural materials and plant equipment. Such a schedule should show all steps required to put the plant into full operation.

At all stages in the construction program close cooperation is necessary between the engineers and the management. Weekly job meetings, with representatives of all contractors present, are an excellent means of ironing out the inevitable delays and insuring the early arrival of the big day when the plant is finally ready to start.

Structure Trends in Chemical And Process Plants

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Structures for process industries plants are more often built around the process than in any other field. Usually the flow sheet calls for a single-story building, although this may be a high one so that equipment can be supported at varying levels. The author considers various building types and draws some conclusions regarding relative advantages, disadvantages and costs.

BUILDINGS to house chemical and process plants are probably more frequently governed by the type of equipment to be used in manufacturing than any other type of industrial building. In fact, in many instances the building becomes merely an inclosure to protect the process and the equipment involved from the weather. Still, there are cases where the structure is designed to support a very considerable amount of equipment at various levels within the building itself while, on the other hand, particularly where process and climate will permit, there is an increasing tendency to use process equipment and machinery of an outdoor or unhoused type. Such an installation is shown in Fig. 1, a view of the Westvaco Chlorine Products Co.'s magnesite plant at Newark, Calif., where climate and process are both favorable to this kind of installation.

It is interesting to note that this plant is of a very high type, housed in buildings framed with structural steel but covered mainly on roofs and sidewalls with galvanized iron, a comparatively inexpensive material which can often be used where chemical reactions of a mild or non-corrosive type are to be considered.

Early in the analysis of the types of structures to be used for any chemical or process plant is found the necessity for a decision between single- or multi-story design. Many plants with heavy equipment are of necessity of one story. In buildings of this sort the heavy tanks, kettles or other vessels may be carried directly on the ground. In other cases where they must be elevated for gravity discharge or other reasons, it is still desirable to support them on structural or concrete members as close to the ground as possible.

In general, it is usual to consider the single-story type of building as more desirable for chemical or process plants, unless high cost of real estate, the unavoidable necessity for location in congested areas, or other equally pressing reasons make it advisable to go to a multi-story structure.

In spite of this general rule, there are many types of process plants where multi-story buildings of reinforced concrete or structural steel are preferred in order to use gravity distribution for materials in process after the immediate hoisting or pumping of raw materials to the upper stories. Sometimes this is best accomplished with a high single-story building in which the equipment may be cascaded, but is supported on its own foundations, independent of the building.

Industrial buildings ordinarily divide themselves into a few simple types about as follows:

1. Flat-roof buildings may be either single- or multi-story and are often used where it is advisable to house a number of tanks or other vessels or equipment on or above the roof. While there are a good many flat-roof buildings in use in the chemical industry, as well as in many other manufacturing uses, it is usually advisable to eliminate traffic of any sort over roof surfaces in order to avoid possible mechanical damage or punctures which will result in leaks. Many plant operators feel, too, that it is advisable to get water and snow off the roofs as soon as possible and therefore frequently insist upon pitched roofs with fairly steep angles.

2. Pitched-roof buildings may be of single- or multi-story design. In either case this type of roof is often combined with a monitor which may be designed to give additional interior daylighting in the building or to be equipped with louvres for ventilation. In many cases ventilated types of sash provide both ventilation and interior illumination.

3. Sawtooth buildings are usually best located with the glass in the sawteeth facing directly north. This arrangement provides uniform interior lighting without direct sunlight and means that dark corners can be avoided anywhere inside the building. However, the sawtooth type of structure is not a good ventilator, particularly in large areas where artificial ventilation in some form or other is normally provided.

If these three types of buildings are constructed of the same materials and with the same overhead clearances, it is probable that at this time their costs will be substantially equal, except that where a considerable expanse of wire glass is required in the sawtooth type because of the use of sloping instead of vertical glass in the sawteeth, the cost per square foot of the sawtooth building is likely to be a little in excess of the two other types.

Any of the three types of buildings may be built of timber, of structural steel or of concrete. In general, the wooden buildings are less expensive than those framed with structural steel. In most cases one-story structural steel buildings are less expensive than reinforced concrete structures for similar use. On the other hand, in certain types of multi-story structures, reinforced concrete is more economical. In chemical and process buildings timber is sometimes undesirable because of its tendency to decay when alternately wet and dry. In the South, timber

cannot be used on or too near the ground because of intensive attacks by termites, and if kept in use too long, dry rot may set in to weaken the members of the structure.

Where structural steel is used, particularly in plants where corrosive vapors or gases are released, the steel must be kept protected by proper care and painting, with occasional inspection for corrosion. Even in concrete structures where the reinforcing steel is properly protected, corrosion may still be found. For example, so mild an acid liquid as vinegar will quickly eat away the surface of even the hardest of concrete floors and attack the rest of the slab actively unless such damage is promptly repaired and kept under control.

Structural steel is frequently the most desirable construction material because of the readiness with which long-span members can be used to provide clear areas and unobstructed floor space, or where heavy crane runways or supports for heavy equipment are required. It is sometimes desirable to use a multi-story structure with a structural steel framework, either unprotected or fireproofed, with concrete floor slabs. This results in the use of columns with much smaller dimensions than those of heavy reinforced concrete. Such a design also makes it possible to cut through the floor slab readily for changes in equipment arrangement, without the undesirable possibility of interfering with important bands of reinforcing steel.

One important chemical manufacturer several years ago standardized on a structure with steel columns, girders and floor beams. On these he laid a floor slab of 3-in. dressed and matched lumber covered with a waterproof membrane made of roofing materials. Above this he laid a 2-in. slab of concrete to provide an operating floor surface for his equipment. His considered opinion of this arrangement is that it results in the best possible combination of materials for a hard and lasting wearing surface for traffic, protection from moisture for the wood floor and above all, a slab through which large or small openings can readily be made in the event of changes in process equipment.

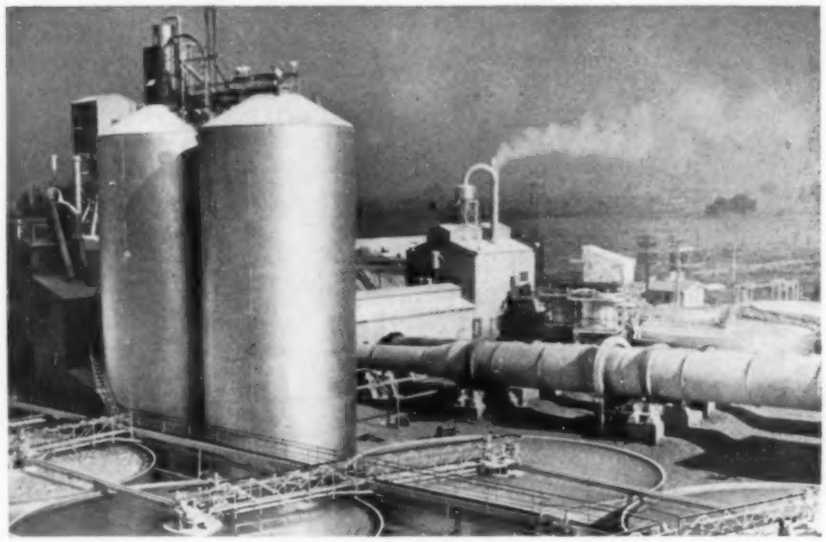


Fig. 1—The outdoor or unhoused type of plant is typified by the magnesia products works of Westvaco Chlorine Products Co., at Newark, Calif.

In the choice of construction materials, as well as in the type of structure itself, it is apparent that the advantages and disadvantages must be carefully weighed in order to provide proper and economical housing for plant equipment. Regardless of the type of structure, the question of exterior materials for roof and sidewalls has an important bearing on the cost of the building. While most good plants still use brick or concrete for exterior walls, during recent years a good deal of corrugated asbestos or similar material has found its way into buildings for chemical and process plants. This material may be seen at the extreme right of Fig. 2, showing of the Champion Paper & Fibre Co. plant at Houston, Texas. Here it is in use as a temporary end for a multi-story building, to provide for quick extension by removal of the large sheets of corrugated material.

Fig. 2—To facilitate future expansion of the Champion Fibre plant at Houston, Tex., a temporary building end was constructed of corrugated siding

Concrete *per se* is not regarded as a good material for exterior walls of buildings unless extreme care is used to make it very dense and waterproof. Even when this is done it is important that the exterior be protected by regular painting with a properly selected exterior coating. This is necessary because of the tendency of concrete exposed to the elements to deteriorate gradually and even to crack or spall sufficiently to expose the reinforcing material. A good many manufacturers have found to their surprise that the maintenance of supposedly permanent concrete exteriors is a matter for serious consideration.

Just as during the last war, when steel in any form was in great demand, there is at present a considerable tendency to revert either to earlier types of wood construction for both framework and exteriors, or to use reinforced concrete which requires materials more readily available, and less steel. The latter is becoming increasingly hard to get and it is probable that as this year progresses, this influence on building design will continue to grow in importance. The trend may become even more imperative if priorities and rationing are applied to structural steel, and to other building materials using steel as a base.

There is also an increasing tendency on the part of the designers of all plants including chemical and process industries, to design for a maximum of shop workmanship and a minimum of field effort. This is largely due to the fact that building labor in the field is becoming ever

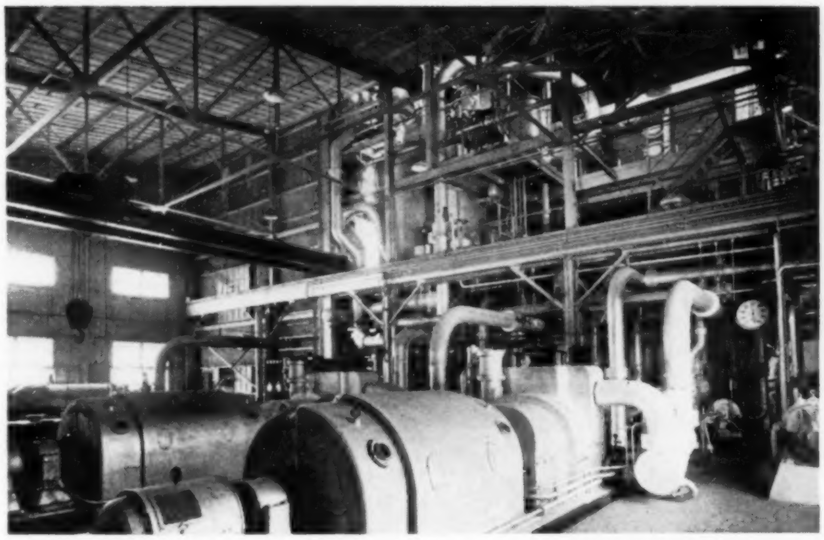


Fig. 3—Corrugated asbestos board was used for the walls, and gypsum planks for the roof slab, in the plant of Southern Alkali Corp., Corpus Christi, Tex.

higher in price while shop labor, although it also tends to increase in cost, is kept at lower levels, partly because of its greater regularity of employment as compared with field labor.

While windowless and blackout plants are now being given serious consideration and occasional use in certain types of defense industries, they have not as yet come into general use in process and chemical plants. The exception to this rule is where it is important to the process to maintain constant temperatures and/or humidities, or where air conditioning is essential for other reasons. Airplane and other types of defense manufacturing plants are now giving considerable emphasis to the blackout feature, which quite possibly may presently extend itself to other types of industry, including chemical and process plants, as the pressure of the emergency increases.

Ventilation in the entire process field is usually of prime importance. For this reason it is customary to design the structures to provide for sizable inlets for considerable amounts of fresh air, at or near the floor line, with proper methods of exhausting either by natural or artificial means.

Power plants usually play an important part in chemical and process industries. Normally their best location is where prevailing winds will keep corrosive gases away from the operating equipment. Usually they are housed in non-combustible structures arranged for easy extension. Such a power plant, as designed and built for the Southern Alkali Corp. at Corpus Christi, Texas, is shown in Fig. 3. The outside walls are of corrugated asbestos and the roof slab is of gypsum plank, which is becoming increasingly useful for this purpose.

Office buildings in chemical and process plants may be of almost any type which the owner of the plant desires. An interesting office building development is shown in Fig. 4. In this, the Mission type of architecture was used for a well-lighted and ventilated two-story office building with single-story wings, built at the plant of the Southern Alkali Corp. The employees' entrance is through an arch at the left, while the executive private offices are in the single-story wing at the right. Since construction, the grounds around this building have been decorated with shrubs and flowering plants so that it now presents an extremely attractive appearance to the employees and the public. Incidentally, a considerable amount of unhoused equipment is visible in the background.

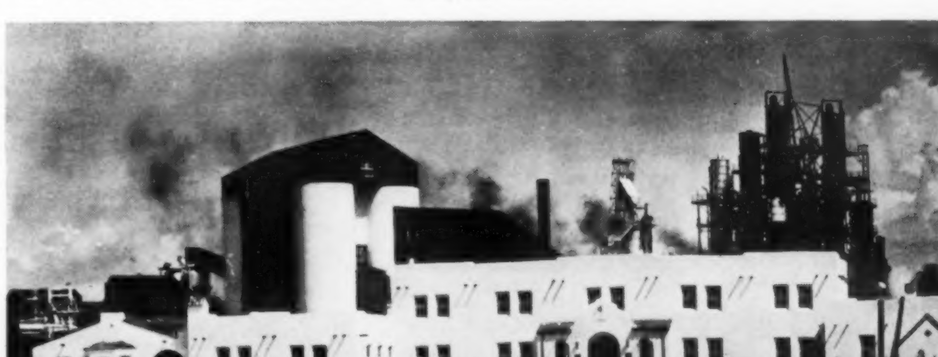
With process changes so frequent in chemical engineering industries on account of the development of new products, and improvements through research, some of the better informed and better financed manufacturers are developing a new technique in the design of their structures. There is an increasing tendency to build easily extendible buildings with larger clearances, both laterally and vertically, than are required for the equipment as originally installed. Such structures, while not much more expensive than the buildings with much closer clearances which were formerly in favor, do allow for a considerable amount of rearrangement of equipment or increase in capacity of equipment. Ultimately they are found to be much more economical owing to the readiness with which changes may be made within the existing limits, often without alterations to the structure.

Many of the larger manufacturers with processes substantially developed, and operating on a volume basis, are using buildings of sturdy design with brick exteriors of a permanent nature. Other corporations, doing a considerable amount of volume business, but with processes still under development or with the particular need for keeping more of their assets liquid, are inclined to use corrugated material for side walls and even wood for roof slabs in an effort to keep down the first cost.

In conclusion, most of the problems to be met in ordinary plant design are encountered in the chemical process field. In addition are certain other problems, such as the support and handling of heavy equipment, frequent replacements on account of high rates of depreciation, the need for exhausting of corrosive gases and liquids, and the necessity for protection of the structure itself.

In the present emergency, with shortages of steel and other critical materials needed for defense work, some changes in design will be desirable and even imperative, at least for some time to come. However, good engineering will rule and proper structures and inclosures will continue to be obtainable.

Fig. 4—Typical of interesting treatments possible in plant offices is the Mission style used in Southern Alkali's plant at Corpus Christi, Tex.



Unhoused Plants a Means of Cost Reduction

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Where they can be used, unhoused and semi-housed types of plant construction are saving goodly sums of money. When properly designed to afford requisite protection for personnel, equipment and materials, they introduce no untoward effects. Climate may influence the choice, but to a less extent than one might expect.

Industrial operations are commonly conducted inside of buildings in order to afford shelter to the workmen, the manufacturing equipment, the raw materials, intermediates and products. Many large chemical manufacturing operations, however, have little need for buildings because the number of workmen per unit of factory space is generally small, the equipment is of such a nature that it either needs no shelter, or it can be protected more economically without a building and finally, the materials needing protection do not emerge from the equipment except at one or perhaps a few points where specifically designed structures afford the most economical shelter.

The trend toward "unhoused" or "outdoor" plants is by no means entirely new. Vertical shaft-type kilns for example, have been unhoused in America since colonial times. Nevertheless, in recent decades there has been an awakening among design engineers to large economic advantages resulting from the unhoused and semi-housed types of construction. This is due in part to the inherent characteristic of factories which makes them more profitable if larger. Also, in America, the southward movement of the center-of-gravity of industry has contributed importantly. In the South, where the weather is less inclement, or rather, inclement a smaller part of the time, it is more obvious that occasional inconveniences caused by lack of housing are becoming less of a factor in the need for shelter.

Sheltering Attendants—For affording shelter to workmen, the general principle involved is so to arrange facilities and the workman's duties that his post is confined to a relatively small volume, where suitable shelter and working conditions can be provided inexpensively. Obviously, if instruments which show the flow rates, temperatures, pressures, concentrations and other evidences of an operator's attention to duty, are all located on a small panel, and along side of each instrument is a push-button, hand-wheel or lever with which he can control the operations in his charge, he needs only a "pup tent" of a house around him. With modern remote instruments a single workman can control as much operation as he has mental capacity to understand and interpret, provided only that it is possible to make all necessary periodic adjustments in the order of their necessity, before the first in the cycle again demands attention. This factor is generally minimized by substituting automatic control equipment wherever feasible.

MAINTENANCE PROTECTION

Besides the operating workmen, there are maintenance workmen and others, such as "sample boys," who occasionally or periodically serve the manufacturing equipment and must be sheltered. Here again the problem is to confine the number and sizes of places needing attendance. For example, several pumps on a piece of equipment, with only slightly greater investment in longer piping, can usually be assembled in a single room, where housing will be much cheaper, and maintenance cost reduced because of economical crane, vice or bench facilities, and simplification of maintenance supervision. A similar expedient is the centralization of lubrication, and another, carrying sample lines to a central control room for routine filtration or automatic sampling.

The principles affecting a decision on the extent of housing are not well understood and are at times quite surprising even to those designers who have made considerable use of unhoused plants. One startling fact is that, in many areas, even some of those where the total precipitation is high, the percentage of the time during which rain is falling is very small. A structure intended to shelter maintenance workmen for occasional jobs which, 99 times out of a 100, is actually furnishing no shelter, would seem not to be entirely economic.

Shelter of Equipment—The shelter of equipment involves protection of the equipment from adverse effects of the weather, the local atmosphere and any destructive effects of adjacent operations. It is relatively simple to protect most machinery from the weather. However, it is difficult to protect some kinds entirely from damage by fine, abrasive particles. For such machinery, a relatively small dust-tight house construction, arranged to bring fresh air in through an effective dust filter, is the most satisfactory solution for routine operation. However, the house must be big enough to permit setting the parts of the machinery down during dismantling for maintenance, and still give workmen room to work. Likewise, the building must support the crane-rails or similar hoisting tackle for such occasional maintenance work.

For other equipment like rotary kilns or even more static machinery, protection may be needed against the several effects of the ambient atmosphere. A large distillation unit or contacting tower is a good example. It is often necessary to protect the contacting tower not only from the corrosive effects of the local atmosphere with proper paint, but also from changes in heat effects. In some cases the heat lost is of negligible value and yet can so upset the control that it becomes necessary to provide adequate insulation. For example, there may be a tremendous difference in heat loss between sunshine and shade, when uninsulated, or between still air and moderate winds. A layer of heat insulation covering the entire exterior of the equipment often serves even better in this respect than the usual type of factory building, although cases will be found in which the reverse is true. Usually a relatively simple comparison will permit a decision regarding extent or scope of housing and insulation.

Heat insulation, as a general thing, requires careful protection from the

weather, not only to prevent loss of insulating properties, but also to avoid leaching. Protection from rain requires a fairly strong outer coating, finished off with a waterproof or repellent layer or film. Additional protection of this film is often required by the local atmosphere. The commonest error made by designers in insulating unhoused equipment is to fail to provide for maintenance access. Mechanically strong and readily removable sections, with a place provided to remove them to, all too frequently are considered adornments rather than necessities.

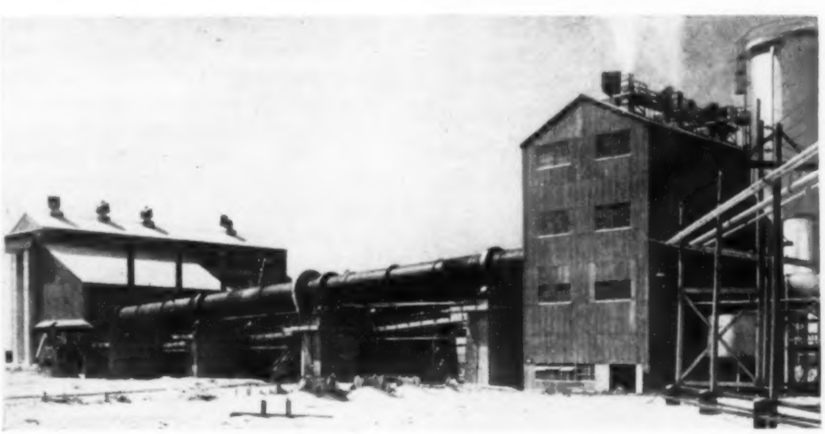
Frequently the unhoused plant is condemned because some minor design feature was neglected. An example might be the freezing of certain small pipe lines connecting to instruments. The fault here is not in the principle of the unhoused design, but rather in improper protection of the particular instrument connections. Instrument pipe lines can not be protected entirely with heat insulation. They may be steam traced or provided with strip heaters. Sometimes remote indication by means of an electrical transmission or some sort of telemeter device not sensitive to freezing will be preferable.

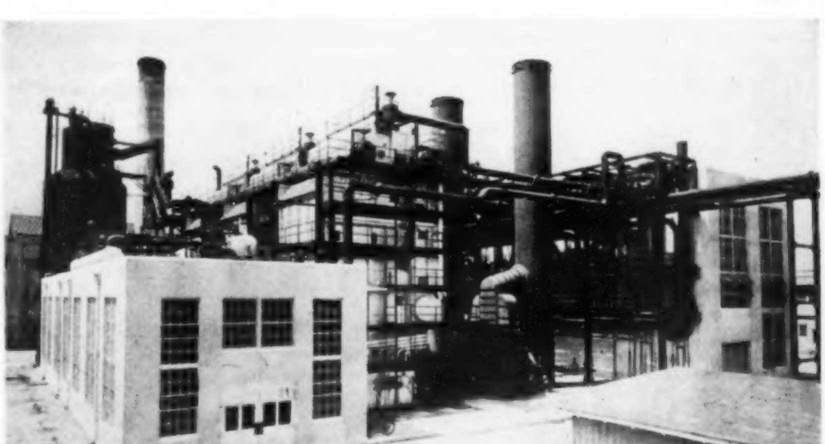
Shelter of Materials—The protection of raw materials, intermediates, byproducts and products from the weather and local atmosphere is generally not as troublesome a problem as the protection of workmen and equipment. Many materials like coal, rocks and ores need no shelter. Obviously, all soluble solid products must be completely protected, as well as products of high purity. Where such materials emerge from the equipment to be stored, packed and loaded, adequate protection is called for and is relatively simple to provide. Many bulk materials are cheaply protected in storage by cylindrical, spherical or spheroidal tanks, the economy of which is influencing design of plant.

From a defense standpoint an unhoused plant has characteristics making it both better and worse than the housed plant. Obviously the unhoused, flood-lighted plant has fewer places where a saboteur can conceal his nefarious activities. Contrariwise, the unhoused plant will be more difficult to blackout and keep operating. Which type presents the more difficult target, or suffers the more crippling damage from various kinds of bomb hits, is subject to inconclusive debate. The skillful camofleur can probably conceal both types. With a direct or near hit from a bomb, a building might save difficulty replaceable production equipment, or it might seriously damage the equipment with some building fragment.

Outdoor kilns for calcining alumina in plant of Aluminum Ore Co. at Mobile

Outdoor installation of Foster Wheeler boilers at Texas Co.'s Port Arthur refinery; firing aisle is at left and turbine room at right; water treatment at rear





OUTDOOR POWER PLANTS

(*Editor's Note:* The following presents results of a brief survey of outdoor and semi-outdoor power plants conducted by the editors with the cooperation of Babcock & Wilcox Co., Combustion Engineering Co., Foster Wheeler Corp. and Riley Stoker Co.)

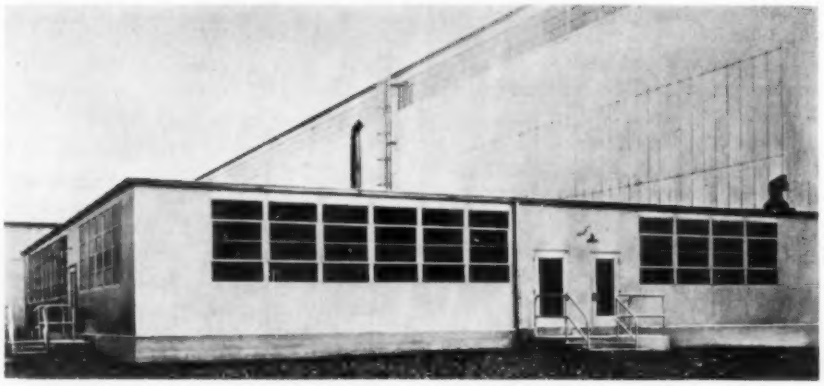
A considerable number of outdoor plants in both the industrial and utility fields has been built in recent years, mostly in relatively warm parts of the country, but several in quite severe regions. In most cases both the operating aisle and the turbine and generator room are under cover, although in several instances, as in General Electric's mercury turbine plant at Schenectady, the turbine and generator shells are exposed, with condenser and auxiliaries housed beneath the turbine. It is claimed that in a complete generating plant a saving as great as 15 percent can be made with a semi-housed plant, as compared with an expensive but usual type of housing, with half this saving possible as compared with a building of plain and relatively light construction.

Nevertheless, power engineers are not of one mind regarding the general applicability of outdoor plants. The move in this direction appears to have abated recently, and there is not as much interest as there was a few years ago, although in all cases operation seems to have been entirely satisfactory.

The following roster of outdoor power generating and steam plants, now operating or building, makes no pretense to being complete: In Arizona is a single utility plant with a steam capacity of 75,000 lb. per hour. California has a municipal plant of 400,000 lb. capacity, and three utility-owned plants operated in conjunction with oil refineries, each of 600,000 lb. per hour. Illi-

nois has one industrial plant of 300,000 lb. per hour, and Kansas a utility plant, of 320,000 lb. per hour. A single industrial plant in New Jersey evaporates water at the rate of 100,000 lb. per hour, while in New York State is the General Electric mercury vapor installation, rated at 20,000 kw. North Carolina has a utility plant of 300,000 lb. and Oregon, another of 225,000 lb. per hour evaporation. Texas leads the list with four industrial plants totalling 2,915,000 lb. and three utility plants, totalling 610,000 lb. per hour. A utility plant of 200,000 lb. evaporation in Utah, and an industrial plant of 40,000 lb. per hour in West Virginia, complete the picture so far as our information goes.

Proponents of outdoor construction point out that with modern equipment and feedwater treatment, major maintenance on power plant equipment can be scheduled for periods of clement weather, so that the lack of housing for such parts as the boilers proper presents no difficulties. Boilers must of course have water-tight casings and exposed motors, as for draft fans, must be of splash-proof construction. Control elements must be shielded from wind and rain. An interesting idea is found in the Provo, Utah, plant where only the boilers are exposed to the mountain storms, but the turbine room is low-roofed, and equipped with an outdoor gantry crane above the structure, by means of which the turbines or generators can be dismantled through roof hatches.



Typical of the buildings prefabricated by the Austin Co. is this building for showers and lockers, erected for the Carnegie Illinois Steel Corp.

Prefabricated and Standard Plant Buildings

EDITORIAL STAFF

Intended primarily to indicate what is available in prefabricated construction, this short section gives details of some of the structures which have been and can be erected with a minimum of man-hours. These buildings may well be the solution to many problems of immediate expansion and future re-adaptability.

In the chemical and process industries, plant buildings are ordinarily designed to house the equipment for a particular series of reactions. Each plant, therefore, usually presents an individual problem of design and construction. With few exceptions, use of prefabricated and standard buildings in the process industries has been largely limited to pump, boiler, and storage houses and similar minor structures. Numerous other industries, particularly those engaged in manufacturing operations, have found them satisfactory for incidental buildings such as garages, workmen's lockers, office buildings, as well as for large main plants.

Shortages and delayed delivery of essential building materials, either because of priorities or unusual demands, could conceivably hamper, to a serious extent, plans for plant erection or expansion. Manufacturers of prefabricated and standard buildings feel they can furnish a solution to many of these problems.

The basic principle behind plant design using this type of construction is the use of a number of standard prefabricated trusses used singly or in combination, together with

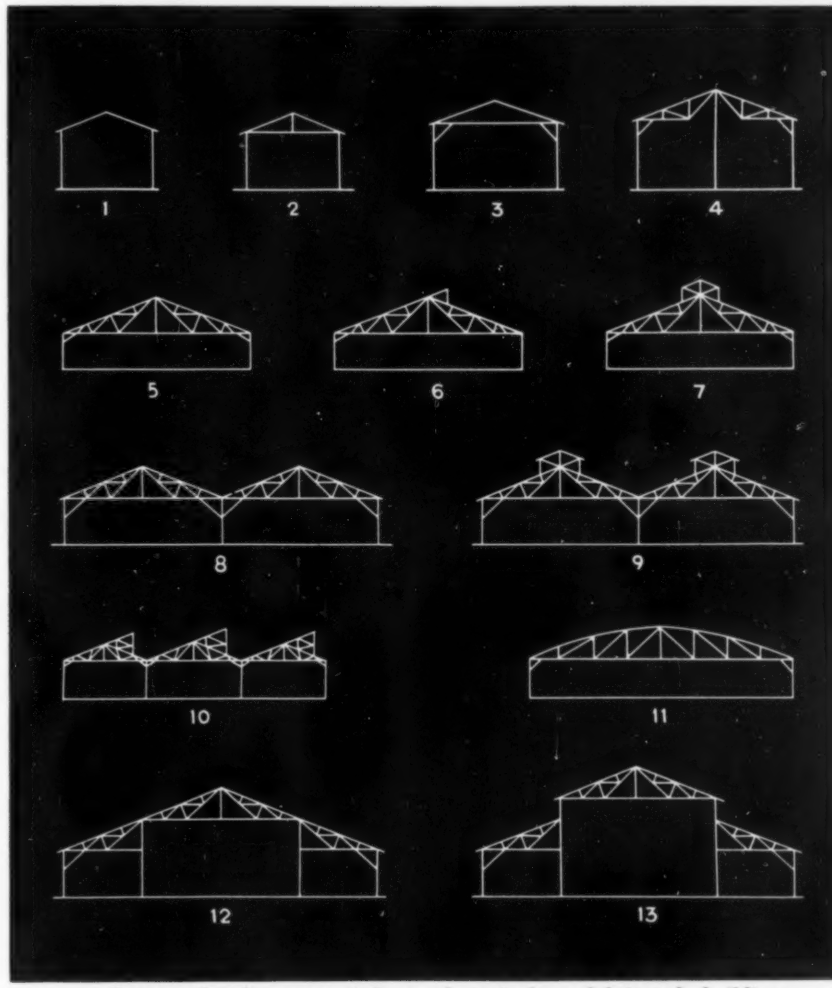
Below left—Special Process Department and Laboratory of the McKenna Metals Co. Building is 40 by 80 ft., 12 ft. high at roof chords. Erected in 30 days by Blaw-Knox. Right—An air-conditioned office building built by American Rolling Mill Co. for Lamneck Products. Illustrates how masonry exterior may be combined with a prefabricated steel framework

framing members, roofing and siding panels to give any desired cross section. The building may be extended in length, usually in multiples of 2 ft., to cover any area. Furthermore, various heights may be achieved in the same building so that, for example, one section can be of low single-story design and an adjacent part of high single- or multi-story type to provide for equipment on several levels. The illustration on the right shows sketches of a few of the cross sections and combinations available.

Standard construction, as distinguished from prefabricated, is usually taken to mean the standardization of certain elements only such as trusses, leaving broad latitude in the remainder of the design. The Austin Co., for example, uses such standard structural cross sections, but also manufactures a variety of prefabricated insulated steel structures suitable for wash and locker rooms, utility buildings and small plant offices.

Advantages claimed for prefabricated construction are numerous. In addition to low first cost, the buildings are fire resistant with consequent low insurance rates. Maintenance also can be made small and a minimum of care usually gives them a comparatively long life. Steel panels destroyed by excessive local corrosion may be quickly and easily replaced. The fact that prefabricated buildings can be largely built under controlled shop conditions, with efficient shop equipment, eliminates much of the field work required with other types of buildings and permits assembly with a minimum of labor and in a very short time.

Standardized construction is responsible for additional advantages: Plant expansion, alterations and contractions may be effected with a minimum of disturbance to existing



Cross-sectional representations of typical prefabricated buildings

These drawings are not of the buildings of any one manufacturer; rather they are intended to indicate what is available. (1) Without any roof truss, this type is used for only the smallest incidental buildings. (2) Similar to the above, this type is used for small buildings; height 8 or 10 ft. and width from 4 to 14 ft. (3) For slightly larger buildings; the bracing allows the use of a span up to 30 ft. in heights to 16 ft. (4) Trusses resting on the center post here permit a total span of 60 ft. (5) The most widely used type; for buildings with clear spans up to 130 ft. The methods of bracing these gable trusses vary among the different manufacturers. (6) Similar to the preceding except that a semi-monitor has been added for light and ventilation. (7) The full monitor. (8) Combination of two gable trusses. (9) Two full-monitor trusses used for one building. (10) An improved sawtooth arrangement; single spans of various widths. (11) Bowstring truss, used for clear spans as great as 130 ft. and, with a center column, to 160 ft. Here again the type of bracing varies among the different manufacturers. Monitors may be included. (12) The three-bay gable or low crane type for buildings of greater width than can be economically supplied in the clear span types, where two interior columns are not objectionable; center span 20 to 100 ft. and sides 20 to 40 ft. (13) High crane, or crane runway type, widely used in the manufacturing industries. Widths as for (12).

Other types which are available but not illustrated above include the hipped warren truss with spans to 160 ft. and the gable-sawtooth with the same maximum width.

Left—Illustrating the combination of three trusses for a single building; a bottle warehouse 141 ft. wide, 177 ft. long and 16 ft. high at the eaves. Erected in Baltimore by Maryland Metal Building Co. Right—A Lindsay Structure. Steel wall panel sheets in this type of building are drawn into tension between flanged members of the steel framework

structures. Manufacturers usually retain a record of all units purchased and can fill an order for an addition to an existing plant with little delay. Alterations are comparatively simple, the buildings may be readily disassembled and re-erected on new sites or stored for future use. Salvage value is high.

MANY TYPES AVAILABLE

Throughout the country there are a number of manufacturers of prefabricated structures and standard shapes. Each has his own patents, methods and materials of construction. All are prepared to offer recommendations and estimates for any new construction requirements which may be submitted. On larger buildings erection service or superintendence is usually the recommended procedure.

Frames, trusses, wall panels and other features vary in details according to the manufacturer. These are, however, individual methods of accomplishing similar results.

Steel framing members, purlins and ridges are made from standard rolled sections and delivered cut to size and drilled for bolts and fasteners. Similarly the trusses required for all but the very small buildings are delivered ready for immediate elevation to position.

Steel side wall panels are usually bolted into place. Joints are made by various methods of weatherproof overlapping. By the addition of clips to which furring strips may be nailed, interiors may be finished with plaster or various types of wallboard, either with or without insulating bats. Wall panels are available in which an insulating panel is sandwiched between steel sheets.

Roofing construction is usually similar to that used for side walls. Both pitched and deck roofs may be readily insulated. Special trim is supplied for eaves, gables, doors and windows, giving a finished appearance and a weatherproof construction to the building.

Both hinged and sliding doors are available in numerous standard sizes and styles. Steel sash windows with or without ventilated sections, with any type of glass, are also furnished as specified. Roof ventilators and skylights can be included, properly flashed to the roof.

Esthetic considerations such as a desire for architectural conformity with existing structures may dictate that new buildings incorporate brick or other masonry construction. Such materials can readily be combined with many of the standard constructions to produce buildings that are quickly erected and of pleasing appearance.

Shortages of steel may cause some curtailment of the manufacturing activities of producers of these prefabricated shapes and building materials. For temporary and emergency structures there is one material of which ample supplies seem assured. The same technique is being applied to wood (pp 106-108). Trusses, wall panels and other components of a building can be prepared in standard sizes ready for immediate shipment to all parts of the country.

The editors wish to express their thanks to the following companies for their cooperation in supplying information used in the preparation of this article: The American Rolling Mill Co., Middletown, Ohio; the Austin Co., Cleveland, Ohio; Standard Building Dept., Blaw-Knox Co., Pittsburgh, Pa.; Butler Mfg. Co., Kansas City, Mo.; Dry-Zero Corp., Chicago, Ill.; International Steel Co., Evansville, Ind.; George L. Mesker & Co., Evansville, Ind.; Stefco Steel Co., Michigan City, Ind.

Building Fabrication and Comparative Costs

HAROLD P. ROUNDS and JOSEPH T. KIERNAN
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Types of framework construction, wall materials and roofing are discussed here with special reference to the chemical process industries. Relative costs are given as well as advantages and disadvantages of the various methods of fabrication.

Engineers engaged in designing chemical plants are faced with the problem of choosing between the various types of building construction each of which has its advantages and disadvantages varying with location, climatic conditions and the kind of chemical industry which the plant is to house.

A nationally known chemical company used the conservative type of construction for a new plant now being built in Texas. Steel columns and beams or trusses were used with brick walls; poured-in-place gypsum for flat roofs and corrugated asbestos for pitched roofs. The steel frame was particularly essential in this instance on account of probable high wind velocities. As a rule, field connections of steel beams were bolted for ease in making future changes and extensions. Welding was used only as an adjunct to riveting and bolting.

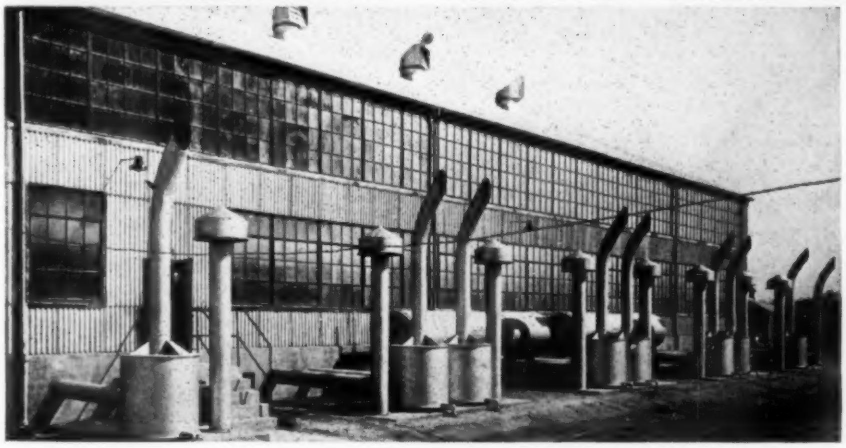
In this same locality there is an oil refinery which employed the wall bearing type of construction. The roof steel work is supported on brick bearing walls without steel columns. This is a cheaper construction but sacrifices some of the stability which goes with the steel framework.

In the natural gas industry, several companies have made extensive use of the type of construction employing sheet iron or asbestos siding on steel framework for compressing stations and auxiliary buildings.

Each industry, and we might say, each company, has its own peculiar requirements, dictated by geographical position, manufacturing processes, and most of all, economy. As the objective is to obtain appropriate, good appearing, durable buildings at a cost which will not be an economic burden, the merits as well as the comparative costs of the various types of building materials should be studied before making a selection.

FRAME DESIGN

The framework is an important element in all buildings and steel, concrete or wood can be successfully employed for this purpose. Reinforced concrete makes an effective building frame and has been used in multi-story buildings where the column spacings are not excessive, but it is not generally adaptable to the long span roof trusses which are needed for industrial work. For buildings of a temporary nature an



Structural steel is the framework material for both of these modern industrial buildings. The illustration at the top shows a brick-wall building with steel sash. The building below has roof and siding of corrugated asbestos; steel sash on the first floor is provided with ventilating sections

economical structure can be obtained with a wood frame and corrugated iron siding and roofing. This type of building while feasible in a warm climate could not be easily heated, and would require constant maintenance to keep it in good condition. For a permanent, non-combustible type of industrial building, the steel frame is widely used and has many advantages. It should be mentioned that in all chemical plants the building steel should be grounded electrically to prevent the ignition of any flammable gases which might be present and it is likewise necessary to fill all pockets and low spots under floor slabs and around buildings to prevent the accumulation of such gases.

The steel framework consists essentially of a series of columns, beams, girders and other bracing members securely joined to form a structural unit. Since the strength of this unit, and to some extent the cost, is determined by the type of connection, it is important that structural connections be given consideration when planning new construction. The frame may be bolted, riveted or welded. In general the type to be selected depends upon the size of the structure, the unit floor loads and the general use to which the building is subjected. Prevailing labor conditions may also be a factor as both welded and riveted joints require skilled mechanics, and the increasing demand for this type of labor on Defense projects might result in a shortage of qualified men for industrial buildings.

BOLTED CONNECTIONS

Bolted connections made with ordinary bolts are satisfactory for one story industrial buildings which do not carry heavy loads from shafting, hoists, or cranes and which are not subject to vibration. They may also be used in minor connections for framing stairs and doors, and for purlins and girts when these members do not form part of the bracing system of the structure. The bolted connection is simple and economical, it can be readily inspected and the labor cost is less than riveting. It has a distinct advantage over other types of connections in buildings which might be altered or relocated as the connections can be taken apart and readily reassembled.

Riveted connections are the conventional type employed in most building construction and until the advent of structural welding about twenty years ago, were practically the universal type of connection for buildings of a permanent nature. The riveted connection is more rigid, stands up better under vibration and is more durable and safer than a bolted connection. This type of joint is readily inspected and has given satisfactory service over a long period of years.

Welded connections have been employed in structural work for the past twenty years, yet the growth of welding has been slow. The reluctance of engineers to accept welding may be attributed to the development stage through which this new method was passing, but today there seems to be a wider acceptance of welding in the structural field. A correctly designed welded structure should result in a saving of steel over the conventional riveted type. In tension members the gross section can be used to resist stress as there are no rivet holes to be deducted. Welded connections are lighter than the riveted type. Trusses can usually be designed without gusset plates, and the rigid joints obtained through welding make it possible to take advantage of savings in steel due to continuous beam or rigid frame construction. At present, inspection costs in shop and field are greater for welding than for riveting and it is the problem of the welding designer to effect a saving in steel sufficient to offset these extra costs.

The above three methods are often used in the same building. Where the main framework is riveted, the purlins and girts and other secondary members may be bolted, while welding is used on piping and equipment supports, ladders, platforms and other incidental work. Welding is particularly valuable in making alterations to steel work and to secure new work to existing building columns or girders.

The side walls of a building offer a wide selection of materials depending on the architectural effect desired, and the degree of economy to be attained. Brick is the oldest and most common material for building enclosures. If carefully selected it lasts indefinitely and a pleasing appearance may readily be achieved.

In recent years glass blocks have been used in building walls for their decorative effect and for their improved lighting and insulation qualities. They prevent harmful dirt and grit from filtering into the building and are most effective when used in

connection with air conditioning. Glass blocks are more costly than brick and this increased cost must be weighed against their advantages as a building material.

The cost of masonry walls may be reduced without sacrificing the insulating and fire proof properties of brick by substituting hollow tile. The appearance may be improved by plastering either or both sides of the tile, but a good effect can be obtained with a tile having smooth exterior surfaces. Plants built with this material have been satisfactory in appearance and upkeep.

In connection with masonry walls it might be added that it has been found that the use of lime mortar in laying up temporary masonry walls, facilitates the dismantling and reclaiming of the brick or tile when the wall is removed.

In buildings which do not require a high degree of temperature or humidity control, satisfactory and economical results can be obtained by using corrugated iron for side walls and roof. These sheets can be of black or galvanized iron. Black iron, though cheaper in first cost must be kept well painted at all times.

Asbestos protected metal which is used for sidewalls and roofing, consists of corrugated sheet steel encased in coatings of asphalt and asbestos. This type of siding is fire resistant, has an insulating value not possessed by corrugated iron, and is not subject to the action of corrosive gases and acid fumes.

Corrugated and flat asbestos sheets consist of a composition of asbestos and cement combined under a high pressure. The sheet is hard and smooth and makes a light and permanent fireproof building which is not affected by acid fumes, moisture or corrosive gases. Asbestos sheets present a pleasing appearance, possess a fair insulating value and do not require painting or other maintenance throughout their life.

In order to show the variation in construction costs resulting from the use of the different types of wall and roof materials mentioned above it is necessary to prepare cost estimates. For purposes of comparison it is customary to express building costs on a square foot or cubic foot basis. These unit costs are influenced by many factors; the type of construction, local labor and material costs, the size of the building, the ratio of wall perimeter to floor area, etc., and a unit cost derived for one building should not be used in estimating the cost of another unless the conditions are similar. In the tabulation shown below the cubic foot costs are given for a one story simple type of industrial building 60x150 ft. with an average height of 35 ft. The building is of steel frame construction, with ordinary concrete foundations, and a 6-in. concrete floor slab. Forty percent of the wall area consists of steel sash and doors. The materials for the walls and roof vary as shown in the tabulation. No allowance has been made for lighting, heating, or other building equipment.

Type of Material		Approximate Cost per Cubic Foot
Walls	Roof	
Face brick, common backing, 8-in. total...	Tar & gravel on gypsum plank	$0.098
Common brick, 8-in	Tar & gravel on gypsum plank	.093
Hollow tile, 8-in	Tar & gravel on gypsum plank	.085
Corrugated asbestos	Corr. asbestos	.078
Corrugated iron	Corr. iron	.073

From the above tabulation it is seen that there is an increase of about 33 percent between the lowest and highest unit costs resulting from varying the type of siding and roofing. The above general figures are governed entirely by the assumptions made for this particular building and will vary with the conditions peculiar to each problem.

It is possible for the cubic foot costs of industrial buildings to vary from $0.05 to $0.06 for a large cheaply constructed type to $0.35 to $0.40 for a well built modern administration building.

In any analysis it should be remembered that low first costs do not always make for economy and that service and durability are qualities which remain after costs have been forgotten.

In summary it may be said that engineers assigned to the design and construction of chemical plants at this time should remember that in no industry is greater progress being made. They will do well to consider the ever expanding scope of the chemical industry and its limitless possibilities before sketching the plans for the buildings that will house its operations.

Wood Frame Buildings

F. J. CHAMPION
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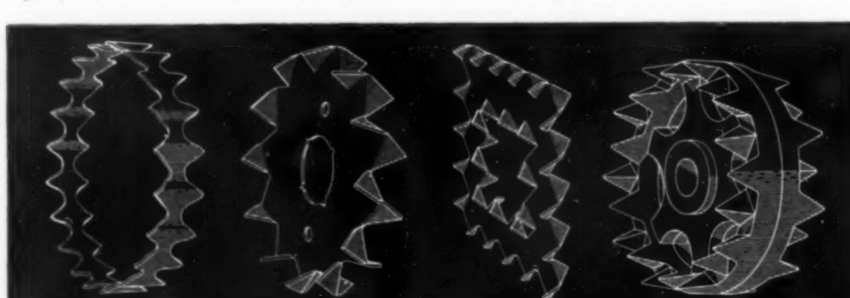
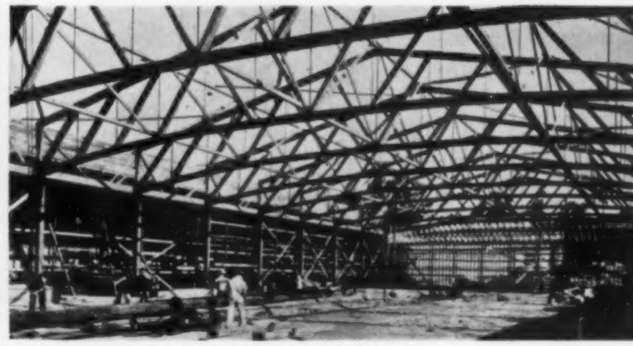
Current and anticipated needs of the chemical industries for emergency expansion find wood ready to serve with an abundance of structural material well adapted to rapid procurement and erection. The technical background of structural timber has been greatly enlarged and a number of innovations have substantially advanced wood in the field of modern industrial usage.

Outstanding new developments in the structural uses of wood include the improvement of plywood to make it an acceptable material for exterior walls and roofs, the utilization of modern metal connectors to improve the efficiency of bolted timber joints, and, newest departure of all, the development of glued laminated wooden arches.

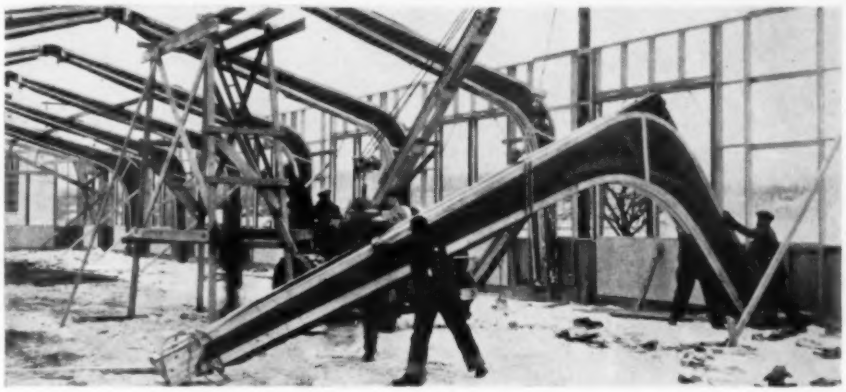
* The Forest Products Laboratory, Forest Service, U. S. Dept. of Agriculture, is maintained in cooperation with the University of Wisconsin.

Typical connectors which are available to increase bearing areas of wood joints

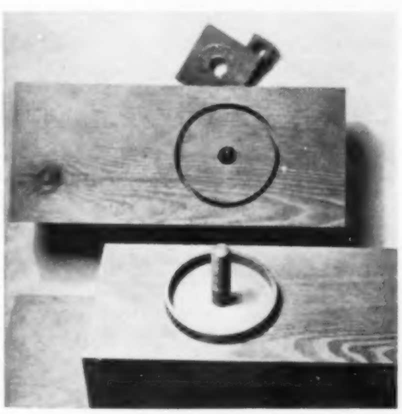




Shapes unobtainable in solid wood can be produced by gluing seasoned boards. Above left — 58-ft. glued laminated arches. Right—Connector joined trusses



Above—Erecting glued laminated wood arches. Left—A modern ring connector and bolt in place in a joint

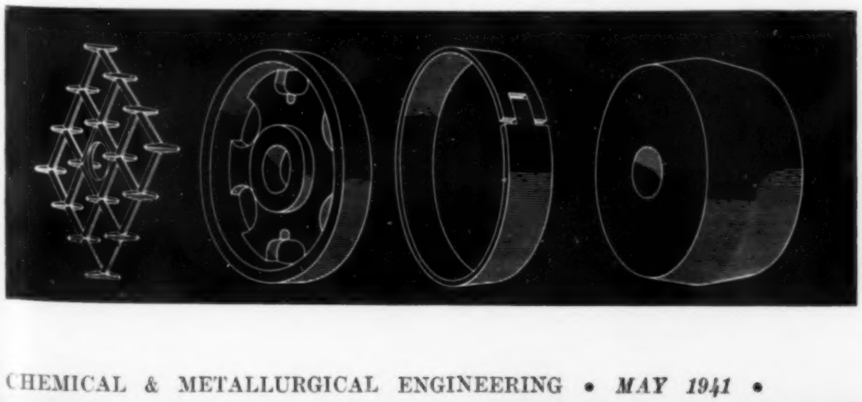


The merits of plywood in general are well established—its relatively small shrinkage and swelling, its toughness and resistance to splitting, its relative uniformity of properties in both directions, its flexibility in the thinner forms, and its avai.abi ity in large sizes (4 by 8 ft. is a stock size). The latter feature adapts it admirably to the rapid erection of buildings, and the use of special types of plywood for concrete work assures smooth forms and permits multiple use of the forms.

Basic to the modern improvement of structural plywood was the development of synthetic resins. When used to bond veneers of structural quality into plywood these resins maintain high strength under the fluctuating moisture conditions encountered by any exterior structural material and resist bacterial, chemical, and mechanical deterioration. Resin-bonded plywood offers more resistance to fire than the older forms of plywood since it does not delaminate and expose fresh wood so rapidly.

The use of synthetic resin-bonded plywood had early applications in large buildings erected for the various world expositions in Chicago, New York and San Francisco. Somewhat later synthetic resin plywood provided the principal material of a number of systems of dwelling house prefabrication which are still under development and which may prove important in the plans for providing living accommodations for hundreds of thousands of "transplanted" defense workers.

Connectors can be supplied in cadmium or galvanized steel or non-ferrous metals



Modern connectors, the engineering background for which was pioneered at the Forest Products Laboratory of the U. S. Forest Service at Madison, Wis., have revolutionized timber design by providing much added strength where strength was most needed—at the bolted joints—by increasing the effective bearing area at the joint. These fittings can be made to serve in any form of timber construction where load is transmitted from one timber to another or from a timber to a metal plate, including the fabrication of trusses and bents. The numerous types of modern connectors fall mainly into three classes, namely, plates provided with teeth, spikes or corrugations; rings, plain or toothed; and disks or wide short dowels. The diameters range from two to about eight in. They are placed between the faces of two pieces to be joined and are embedded in one or both of the pieces. Precut grooves or holes receive the plain rings or disks. Toothed connectors are often forced into position by pressure.

Since the introduction of modern connectors a few years ago more than 18,000 structures in 44 states have been erected with these fittings. An 840-ft. factory building supported by connector-joined trusses was recently completed in the Middle West. The manufacturers can supply connectors galvanized or cadmium coated or of non-ferrous metals.

The glued laminated wooden arch is a new and versatile fabricated timber, made by gluing seasoned

boards together around suitable forms to produce arches of size and shape not obtainable in solid wood. The strength of these arches permits their use without any trussing or bracing so that they may be substituted for trusses and truss-type arches to provide high, wide, unobstructed interiors. On the basis of research at the Forest Products Laboratory the design of such arches may be varied widely to conform to the structural requirements of an industrial building. Arches of the three-hinged type having spans of 120 ft. are already in service.

Laminated wood construction has been especially favored in Europe for railroad and chemical structures because of its immunity to corrosive fumes.

The laminated arches, because of their large size, are fire resistant. Like other heavy wooden structures their failure in a fire would come only after combustion had been sustained for some time, so that they would not complicate the job of controlling a serious fire by early failure with the initial temperature rise.

In connection with wooden industrial buildings there is considerable current interest in fire retardant paints. We know of nothing better in this field than paints containing borax which have been the subject of experiments at the Laboratory. These paints appear to have value in preventing small fires from spreading and getting out of control. The formulas have been published by the Laboratory.

All of the foregoing new structural developments are being used in construction to an increasing degree. The Forest Products Laboratory at Madison, Wisconsin, can supply not only information specific to these modern adaptations in the use of wood, but also basic strength data underlying the successful use of wood in the longer established structural forms.

Personnel Facilities

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Three essentials: cleanliness, accessibility and ventilation, are of outstanding importance in the design of washrooms, locker rooms and other employee facilities. Proper attention to these requisites will not only repay employers in the over-time defense industries but will also prove to be a sound investment for all plants.

ADEQUACY of facilities for the personal convenience of industrial workers has come to be recognized as one of the basic prerequisites of harmonious labor relations. More important than ever as workers swing into the pressure pace of continuous production for national defense, these accommodations should receive serious attention in the planning of any new plant.

Extent and location of lockers, washrooms and toilet facilities cannot be determined by any set rule, for each plant should strive to fit these facilities into its own layout in whatever way is conducive to maximum operating efficiency and optimum working conditions.

Most industries have recognized the necessity for providing individual lockers for all employees, to provide safekeeping of clothes and personal effects as well as for general health and neatness in the plant. In most chemical and other process industries, locker facilities are usually located in special quarters designed for this purpose and situated adjacent to shower and washrooms. Separate buildings are sometimes provided.

Locker rooms are fast disappearing, however, in some manufacturing plants which are free of dust and other atmospheric impurities. Many have adopted the idea of placing lockers right in each individual department where they can be arranged as walls and partitions to separate certain operations from unrelated activities nearby. This practice greatly reduces the time normally lost in going and coming and gives department heads or foremen the opportunity for closer contact with their men.

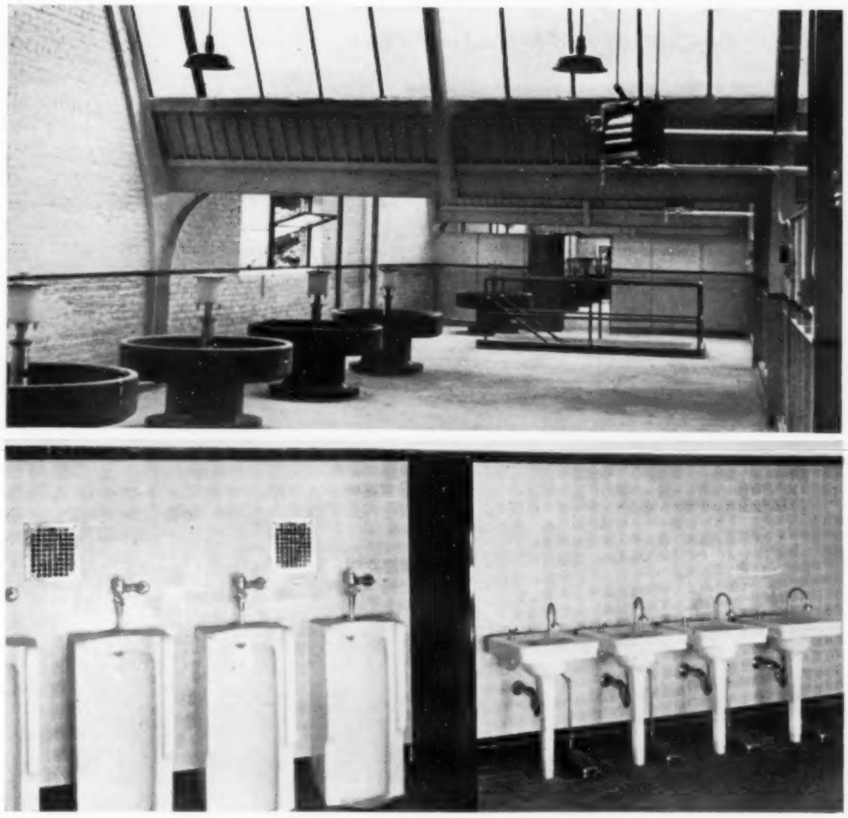
Cleanliness, ventilation and accessibility are the three prime essentials of all personal convenience facilities in the industrial plant. These considerations call for careful design and an intelligent use of materials which promote the highest possible degree of cleanliness. The surest way to win the cooperation of employees in keeping toilets, lavatories and locker rooms clean is to have them that way. The maintenance required to do this can be held to a minimum by the selection of proper materials for fixtures, wall surfaces and floors, and by providing adequate receptacles for wastepaper, towels, cigarets and miscellany.

Many plants are using tile of one sort or another throughout toilet and washrooms because of the ease with which it can be washed down at any time. Metal toilet partitions are in practically universal use and likewise can be easily maintained. By painting ceilings and upper wall areas a clean gloss white or aluminum and keeping the floor as light in color as possible, there is a maximum of reflected light which itself begets cleanliness. Where the walls are painted, dark colors can be used to best advantage up to an average shoulder height so that finger marks and the wear which results from heavy traffic will not show.

Wash fountains in many designs are now available in either stoneware or porcelain enamel finishes. They provide a maximum of washroom capacity within a minimum floor space, and their very design makes for cleanliness.

Single-story plants laid out to permit maximum flexibility in straight-line production today are providing

Cafeteria for the employees at the Elastic Stop Nut Corp.'s plant in Union, N. J.



Above—wash fountains on the mezzanine of a welded rigid frame sawtooth factory. Below—Washroom wainscoating is ceramic tile, wash stands have foot controls for a standard mix of warm water, ventilation is provided through wall openings

for most convenience facilities on mezzanines, clear of the working floor, or underground in basement rooms which can be easily reached from the operating level.

In monitor type plants, mezzanines are built right into the monitors where structural steel can be designed to support this added weight. In other plants where the increasingly popular welded rigid frame sawtooth is used, mezzanines are supported on special beams and columns, and are usually located above service equipment or storage areas where natural daylight is not needed.

Mezzanines are obviously impractical in many plants where high clearances must be maintained below the trusses. In such plants, facilities are usually provided along the sides of the building or underground, as at the Boeing Aircraft Co.'s new 42-acre layout, where coat rooms, four central washrooms, and 17 toilet rooms flank more than a mile of interconnecting access tunnels through which each man reaches his own department.

In windowless "controlled conditions" plants which are now gaining favor because of their automatic "blackout" character, all facilities can be located wherever the production layout dictates. Any special ventilation problems can be met by tying right into the plant air-conditioning system. Several such plants provide a number of two-tier installations with wash fountains on the lower level between rows of lockers, back to back, which give privacy on the working level and are convenient to toilet facilities which are located directly above.

In other windowless plants, such as Simonds Saw & Steel Co. in Fitchburg, Mass., where uniform clearance was desired throughout the five-acre rectangular working area, all of these facilities have been centralized in four building extensions convenient to all parts of the plant and in which toilets, coat rooms, a hospital and all air-conditioning equipment are located.

The need for extensive cafeteria or other food dispensing facilities has been accentuated in many national defense plants by shorter lunch periods and continuous working schedules which sometimes make it impractical to eat anywhere outside the plant.

While many firms still make no attempt to provide a place where their employees can eat lunch in comfort at a table, those who have report that the facilities have been well worth the investment and have probably paid for themselves in the good will, health and working efficiency of their men.

While the extent of food service facilities to handle a given number of men can be held down by staggered lunch periods, many managements prefer a simultaneous shut down for lunch in all departments so that the majority of the working force can eat lunch at one time. Whereas the stagger system enables one to feed more persons in a given amount of space, it usually involves more service labor per meal and deprives the management of the opportunity to clear the entire plant of all production activity for several short intervals each day. At such times power can be shut off if necessary and maintenance crews can take care of miscellaneous jobs without interfering with operations.

In these days when managements are primarily concerned with production problems and might be expected to look askance at anything which has no direct bearing on plant operations, many executives are insisting that some provision for recreational activity be made in their new plants.

The most modest arrangements for recreation—even though they only

300-seat auditorium in an air-conditioned building of the Standard Register Co.

accommodate a small proportion of the men on any single shift—are always welcome. The simplest space can be made attractive by the intelligent application of a little paint, which differentiates the quarters from other portions of the plant. This can be further enhanced by the installation of acoustic ceilings and attractive flooring. And one doesn't need much more than some comfortable chairs, a few small tables for checkers or dominoes, or a couple of ping-pong tables to achieve the desired atmosphere.

The widespread enthusiasm of industrial workers for bowling has recently led some firms, whose new plants are many miles removed from all existing alleys, to provide alleys for their employees right at the plant.

Auditoriums built at other new plants have not only proven very useful and convenient as the site for established company activities, but have actually given rise to new intracompany programs which have fostered a wholesome community of interest among employees as a whole. Given a place which they can use for the asking, employees at such plants have formed dramatic groups, special interest clubs, and scheduled all sorts of social, cultural and athletic activities.

With continuous operating schedules which always force some men to work and sleep when opportunities for normal recreation would be available, such facilities have a special value now. At the same time they can be utilized in conjunction with special training activities required for the national defense program.

Defense Considerations in Process Plant Design

EDITORIAL STAFF

Although it is hard to conceive how military hazards can be a very serious consideration of American industry, sabotage and espionage are factors that should generally be considered in the design of a plant. A few facts about passive defense are also worth knowing.

To what extent the physical design of a process industry plant should be aimed toward its defense against potential saboteurs or espionage agents, or against actual military attack, is debatable. So far as protection against persons is concerned, there is little doubt that certain protective features are desirable in a great many types of plant. Particularly is this true, of course, in any establishment manufacturing materials which in any way are required, directly or indirectly, in the military program. Elementary precautions in the design of such plants are therefore usually desirable.

A much more difficult question to answer is whether the design of the plant should consider, even in the simplest fashion, passive defense against military attack. As has been pointed out in our section on plant location (page 80), most current opinion in the United States considers the possibility of anything more than haphazard and sporadic military attack as so unlikely as to make expenditures for passive defense hardly justified in the case of plants not directly concerned with the munitions program. There are, however, methods of plant design which, at small or even no additional expense, can contribute to the safety of the plant against bomb explosions. Therefore, it may be worthwhile to consider some of these measures.

DEFENSE AGAINST SABOTAGE*

In the main, the measures are elementary and obvious and serve to protect against both sabotage and espionage. The saboteur has many methods of operating but in general his aim to damage buildings, equipment or tools by fire, explosion or other means; to damage vital facilities such as power plants, power lines or bottleneck operations; to damage vital materials; or to injure personnel by fire, explosion, infection or poisoning.

Protection against sabotage, of course, must rest upon human factors as well as upon features of the design and layout of the plant. A proper guard system, suitable supervision of the activities of employees while in the plant, careful investigation of all employees, and a personnel program which will make every employee the enemy of the potential saboteur are all vital. However, they are outside the scope of the present article.

Obviously, if the plant personnel is loyal to the last man, then a combination of methods which will prevent the outside saboteur from reaching his objective will have accomplished the desired protection. Adequate fencing, guarding and lighting of the plant are clearly the solutions to the problem.

In any plant comprising a number of buildings, adequate fencing is essential to prevent entrance to the plant grounds. However, where the plant consists of one building, a fence may be superfluous provided that windows are adequately screened with heavy mesh, skylights are protected, coal chutes, sidewalk elevators and outside fire-escapes are so arranged that they cannot be entered from the outside. Most plants comprising two or more buildings should be fenced. Provided the grounds are adequately policed, an exceptionally high fence is ordinarily not required. Three or more strands of barbed wire supported on sloping arms extending *outward* from the fence should be used at the top. One factor to watch, however, is that the barbed wire guard should not extend outside company property, since local ordnances frequently prohibit the extension of guards over public sidewalks or highways, or over adjacent property.

In the case of lighting the plant grounds, no definite rules regarding light intensity or placing are recognized by authorities on protection. The usual stipulation is that lighting be sufficiently strong at all points in the grounds—particularly near buildings—so that an intruder cannot escape detection and recognition by the guards. Too much light is preferable to too little and one arrangement sometimes used is to provide extra banks of floodlights controlled from one or more central points, which can be switched on in case the guards detect anything of a suspicious nature.

Several general principles regarding the layout of plant buildings, particularly with reference to employee facilities and methods of entrance and exit to the plant, have been formulated. Obviously, while the entire plant should be protected, the greatest care must be devoted to especially vulnerable points such as power-houses, power substations, fire protection equipment, critical processing points, explosives dumps, offices where confidential material may be stored, and similar points. The plant should be so

* In the case of plants in the munitions field, which have already been constructed and which have been certified to it by the Army or Navy, the Federal Bureau of Investigation will make surveys and recommendations for protective measures against sabotage and espionage. For plants not already constructed, and particularly plants not directly concerned with defense, this is not available.

laid out that interdepartment movements of the personnel will be minimized. To this end, employee entrance gates should be placed so that employees of particular departments, entering through these gates, will not have to traverse other departments. An extension of this principle dictates that washrooms, locker-rooms, rest and recreation areas, and lunchrooms and cafeterias also be placed so as to minimize interdepartment movements. In large plants, these facilities should be duplicated if possible at various points in the plant. Adequate facilities should be provided in locker-rooms so that packages brought into the plant need not be carried to the place of work. A parcel-checking service at each main gate will eliminate need for inspection of packages brought by employees, but not needed in the factory.

Entrances to the plant should be as few as possible consistent with other requirements. All entrances, furthermore, should be capable of adequate guarding. In the case of employee entrance gates, arrangement should be such that employees enter single-file for identification and any necessary inspection. When it is possible to locate shipping and loading platforms near the boundaries of the plant, the necessity for entrance of trucks and delivery men is thus eliminated. Since inspection of employee automobiles is in most cases impracticable, employee parking lots should either be outside the main plant fence, or, if inside, fenced off so that employees entering the plant area proper must enter on foot and pass a guard. Track-siding entrances should be provided with a gate which can be securely locked when not in use. At all times when the siding gate is open, adequate guards should be provided to inspect all incoming or outgoing cars. Wharves should be similarly protected.

Obviously, since fire, either with or without explosion, is one of the most favored methods of saboteurs, it goes without saying that fireproof construction and adequate fire protection are foremost tools in the defense against this agent.

PASSIVE DEFENSE

Passive defense of industrial plants against enemy action, has a two-fold aspect. The first, the location aspect, has already been considered in our section on plant location. In addition, certain design factors tending to minimize either the possibility of a bomb hit, or the damage from such a hit, are worthy of consideration. Always remembering that the possibilities of a hit are slight, still there is some value in knowing what precautions can be taken.

European practice is, of course, based upon a totally different set of conditions that are likely to be encountered in the United States. With every European capital within bombing distance of airfields within Axis countries, it is logical that Europeans should attempt first to hide the plant, then to provide personnel shelters.

British practice in camouflaging industrial plants is to make them look as much like nature as possible when viewed from the air. Trees and shrubs are used and sharp angles and straight lines are avoided as far as possible. In construction of the buildings, maximum **fire-resistance** is sought and plants are so laid out that each building will, as far as possible, be independent of the others. When wood is used in the construction, it is fireproofed or painted with fire retardant paints. Where buildings are congested, design is based upon the assumption of direct hits and the construction is such that the roof, walls and windows may be readily blown out. Where buildings are widely spaced, it is assumed that only external hits will occur, in which case the building is designed with all elements of high strength. Wall openings are kept to a minimum.

The British remove powerhouses and water towers as far as possible from other structures and isolate especially critical operations in bombproof buildings. The so-called blackout or windowless plant has also become popular in England. One important factor discovered by the British is the desirability of using standard building equipment in so far as possible, to facilitate its replacement. Shelters are regularly provided and when possible, used for other purposes also, such as employees' locker-rooms. These shelters are sometimes designed only for protection against concussion and flying fragments and may be either above or below ground. Others are proof against light and medium bombs. For maximum safety and for protection against a direct hit of the largest bombs, a depth of 60 to 80 ft. below ground is required.

British experience has shown that fire protection is of first importance in industrial plant defense. To this end, auxiliary water supplies are essential, such as numbers of supply tanks sunk below ground. Numerous portable fire-fighting units are maintained together with many scattered supplies of sand for the extinguishment of incendiary bombs. Duplicate facilities for fire protection, as well as for power distribution and other necessary services, are provided.

In all countries abroad, proper means of blackout are emphasized. In the early stages of the war, the British encountered some unusual effects in attempting to blackout plants by painting the windows. One effect was considerable glass breakage under direct rays of the sun, owing to the absorption of heat by the paint film. Another was that closing normally opened windows often resulted in inadequate ventilation, with a loss of employee efficiency and occasionally other adverse effects such as the accumulation of poisonous or explosive gases. Adequate ventilation, usually artificial, is now emphasized in all buildings subject to blackout. The provision of light traps at the building vents introduces additional resistance into the ventilating circuit which must, therefore, is oversized to insure desired results. It is now regarded as better practice to provide adequate shutters or shades outside window glass than to rely upon paint.

A similar philosophy of plant protection is found in other European countries. In most cases, defense plants cannot be removed to safe distances. Both in France and in Germany, therefore, many essential plants have been put under ground, often in abandoned mines and quarries. Particularly in the case of metal-working plants, such as airplane engine factories, this practice has introduced the need for air conditioning of underground spaces to limit the humidity and avoid condensation and rusting and metal tools and parts. In both countries extensive use has been made of underground storage for dangerous and essential materials such as explosives and petroleum products.

PASSIVE DEFENSE IN U. S.

To some extent the windowless type of blackout plant has been built in the United States in recent years. So far as is known, however, no company in the chemical or process industries has gone all the way in this direction. Apparently, all of the completely windowless plants so far erected here have been for precision work, almost all of them in the metal-working industries. Windowless plants do not appear to fit well into the requirements of many process industries. Pharmaceutical manufacture might be one type adapted to this sort of construction. Rayon manufacture might be another. In general, processes requiring air conditioning and making use of large numbers of operatives are those best adapted to blackout construction.

For plants such as those for the manufacture of aircraft, the Army appears to prefer the use of windowless buildings, if possible. It recommends solid walls and roofs for power plants. The Assistant Secretary of War has issued a list of recommendations entitled "Passive Defense Protection for Munitions Plants—Minimum Requirements." As regards civilian plants, these requirements are actually only suggestions. Briefly summarized, the requirements are as follows: Structures should be placed against the side slope of hills and in clearings in woods. A regular pattern of structures should be avoided and buildings should be placed not closer than 200 ft. apart, if possible.

In buildings in which operations must be carried on continuously, arrangements should be made for the installation of exterior opaque shutters or curtains which completely prevent escape of interior light. Sky-

lights should be avoided. Entrances should be constructed with light traps and artificial ventilation means should be provided sufficient for an 8-hour period. Exterior lights needed for safe pedestrian and truck traffic in the yard during blackouts should provide for quick installation of blue covers.

Window areas should be reduced to a minimum and windows should be placed as high as practicable above the floor level since bomb splinters are projected on a minimum angle of about 15 deg. with the plane of impact. Wire- or other type of shatterproof glass should be used. Light-proof shutters should be of adequate strength to prevent opening by an air blast. Fire walls inside buildings should be sufficient to localize fires. Normal fire protection equipment should be supplemented with sand bins and portable equipment.

The recommendations also consider the provision of splinter- and light bombproof shelters, below ground if possible. Later construction of light bombproof storage spaces for essential spare equipment is suggested. An important recommendation is that a plan should look toward eventual duplication of each utility service such as water, gas and electric power, perhaps with a small standby generating plant. Overhead transmission of essential services should be minimized, and fuel supply tanks placed underground, not inside buildings. So far as possible plant outlines should be concealed by location in wooded and broken terrain, by landscaping plans, by protective discoloration, coupled with various other camouflage methods.

Materials for the Building

HAROLD DRAPER VERNAM
Architect, Brooklyn, N. Y.

This quick survey of what goes into an industrial building does not pretend to be exhaustive. For an encyclopedic treatment, the reader is referred to some of the excellent catalog compilations that are published in the architectural field. The chief aim of the present article is to discuss a few of the more troublesome points in building materials, and particularly to note some of the newer things.

With every decade our buildings become more specialized and more complex, giving the engineers and others who design, construct, and maintain them new problems to attack, and aggravations of old ones to solve anew.

Gravitation, wind pressure, heat and the need of it, sunlight and darkness, dust, rain, ice, and snow are old enemies, always attacking and always beaten back. But greater concentrations of loads, higher and longer structures, delicately adjusted processes, 24-hour operation, and other factors keep the draftsman, the chemist, the engineer, and the manufacturer as busy with problems of building materials and equipment as are the users of the completed structures with their own processes. A few of the things that go into buildings are described here, with the emphasis on some of the newer developments.

Foundation problems were old enough when the Bible was written to be used to point a moral. Only of recent years, however, have we invented methods that are sure-fire solutions for almost every condition.

In the design of building foundations it is first necessary to determine the bearing capacity of the soil, which is accomplished by test borings, or the use of loaded test piles. When the bearing capacity is found to be insufficient for ordinary footings, special methods of support for the foundation are required.

One way is to use piles. The trunks of straight, strong trees, driven in upside down, are adequate for many situations. However, if the soil is alternately wet and dry, such piles will rot and in this case concrete-filled steel is generally used.

One method is to drive into the earth hollow steel tubes, slightly conical in shape, proportioned like the tree-trunk pile, until they can be driven no farther, or only a trifling amount at each blow. Then all are cut off at the same level and filled with concrete. The conical shape of the piles compresses the earth, so skin friction finally stops them. To increase their bearing capacity one form has annular ridges throughout its length, another is corrugated longitudinally as in Fig. 1.

If preliminary tests have shown soft earth to a great depth, permanently wet for the lower strata, wood piles are driven first, to be capped with concrete filled tubes or pre-cast concrete cylinders for the upper length.

When rock or other very solid material is encountered, skin friction need not be depended upon for support. Steel tubes are driven until they stop, then, after removal of the earth from within the tube, filled with concrete (Fig. 2) or, occasionally a steel column is put down inside each tube, cased in concrete.

A variation, when moderately solid earth is encountered, is to force concrete down the tube under pressure of a plunger, so that it mushrooms out below the tube, forming a broad foot to sustain the superimposed weight, as in Fig. 3.

To prevent subsidence of an existing heavy structure when an excavation is made adjacent to it, or a subway is run nearby, has been the object of a system known as "underpinning," also used to raise buildings that have already settled, to brace failing retaining walls, and so on.

This is a variation of the steel tube method. Instead of driving the tubes by blows they are pushed down by hydraulic jacks, two for each tube, the upper bearing of the jacks being against the wall to be supported or against short steel beams, known as needles, put through or under the walls. When the gage showing hydraulic pressure indicates that a tube is supporting its designated load a short steel column is wedged in place between the tube and the load. Tests have shown that when the pressure is removed from a pile, it tends to spring back slightly, and upon reapplication of the pressure, will penetrate farther than at first. To prevent this and avoid further subsidence of the building, frequent practice is to drive the wedges while the jacks are still in place and the pile loaded.

CONCRETE

Despite the simplicity of the process of making concrete—so much stone or gravel or cinders, so much sand, so much cement, and so much water, plus, at times, a little of something else, all stirred up together—

a very large part of the concrete used is not nearly as good as it could be. Why? Because another ingredient has been omitted: brains. The lack of this last ingredient is usually evidenced in the use of too much water and too little mixing. It is fortunate that on many jobs the concrete does not have to be particularly good, provided there is enough of it. For important work enough brains are commonly added.

When concrete is at its best it is capable of accomplishing almost astonishing things, which would require a book to describe. It is well to bear in mind that some common impressions about concrete are derived from the faulty performances of poor stuff, and the use of it in particular circumstances should not be vetoed hastily. Brief references to a few items only are made here.

Vacuum Concrete—In order to make concrete sufficiently dense, to give high strength, as well as a fair degree of waterproofness, it is necessary to keep down the water content of the mix as much as possible. In the past, the foremost method of placing such a dry mix has been to tamp it manually into the forms, or flat, as the case may be. In the last few years a process for accomplishing the same end more expeditiously has been developed, in which the concrete is vibrated mechanically. Still a newer method is the patented process of using a mixture with more than proper amount of water, so as to obtain good flowing characteristics, and then removing the excess water by sucking it out with special mats manifolded to a vacuum pump. By means of this process concrete can be made dense enough in ten minutes so that it can be walked on, and finished off with a floor machine. The mats, which are approximately 3 x 4 ft., can be laid side by side on a horizontal concrete floor, or placed inside the forms for the vacuumizing of a foundation wall.

Speed—Quick-setting portland cements, whose setting time can be controlled either by the manufacturer, or by admixture of special ingredients at the job, make faster construction feasible and mid-winter work practicable. The action of cement being a chemical one, not a drying-out process, once the concrete has set, little if any harm will be done by freezing. Heating of ingredients and other precautions insure sufficiently early setting so that shutdowns until the weather moderates are now seldom necessary.

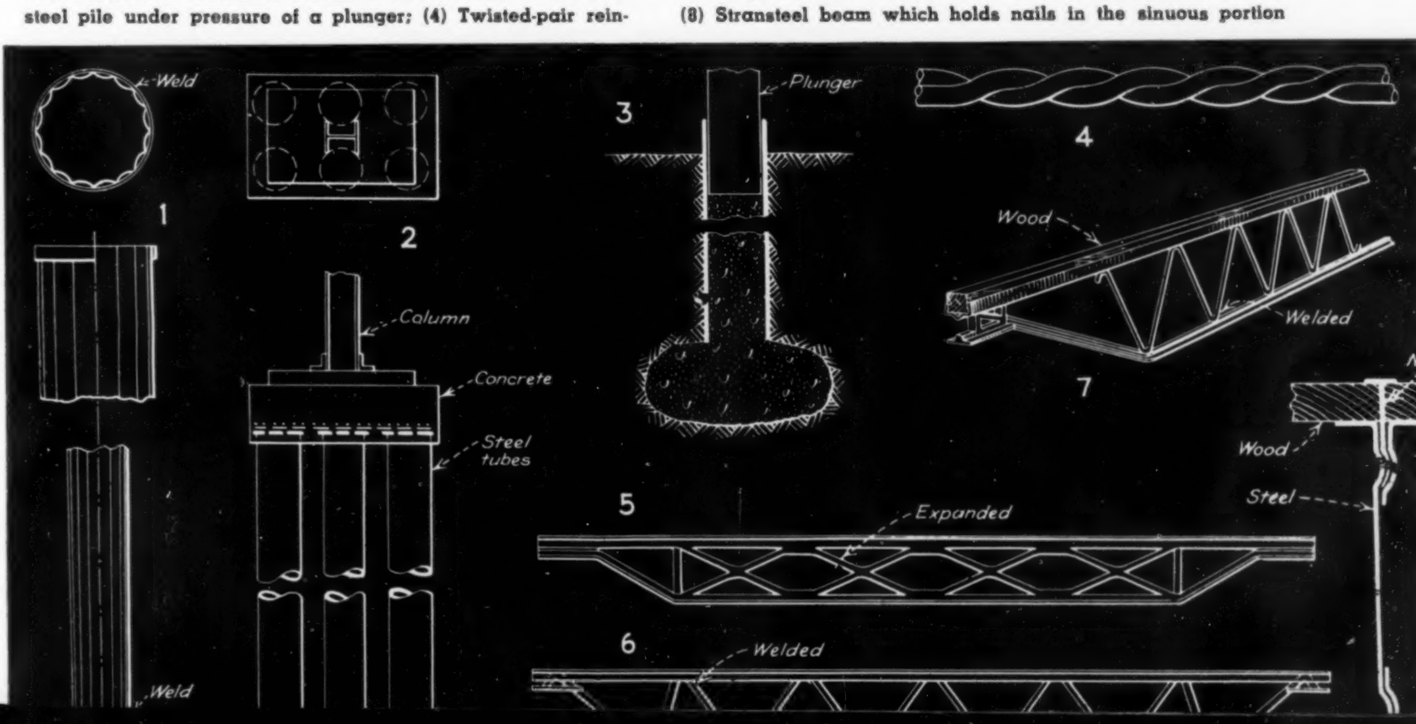
Reinforcement—The small percentage of steel used in strengthening concrete, and that in easily obtained mesh or bar form, may make its use particularly advantageous if shortages in structural steel develop. Such a shortage may occur because of too much work in the fabricating shops, even though the mills may still be able to roll the shapes desired.

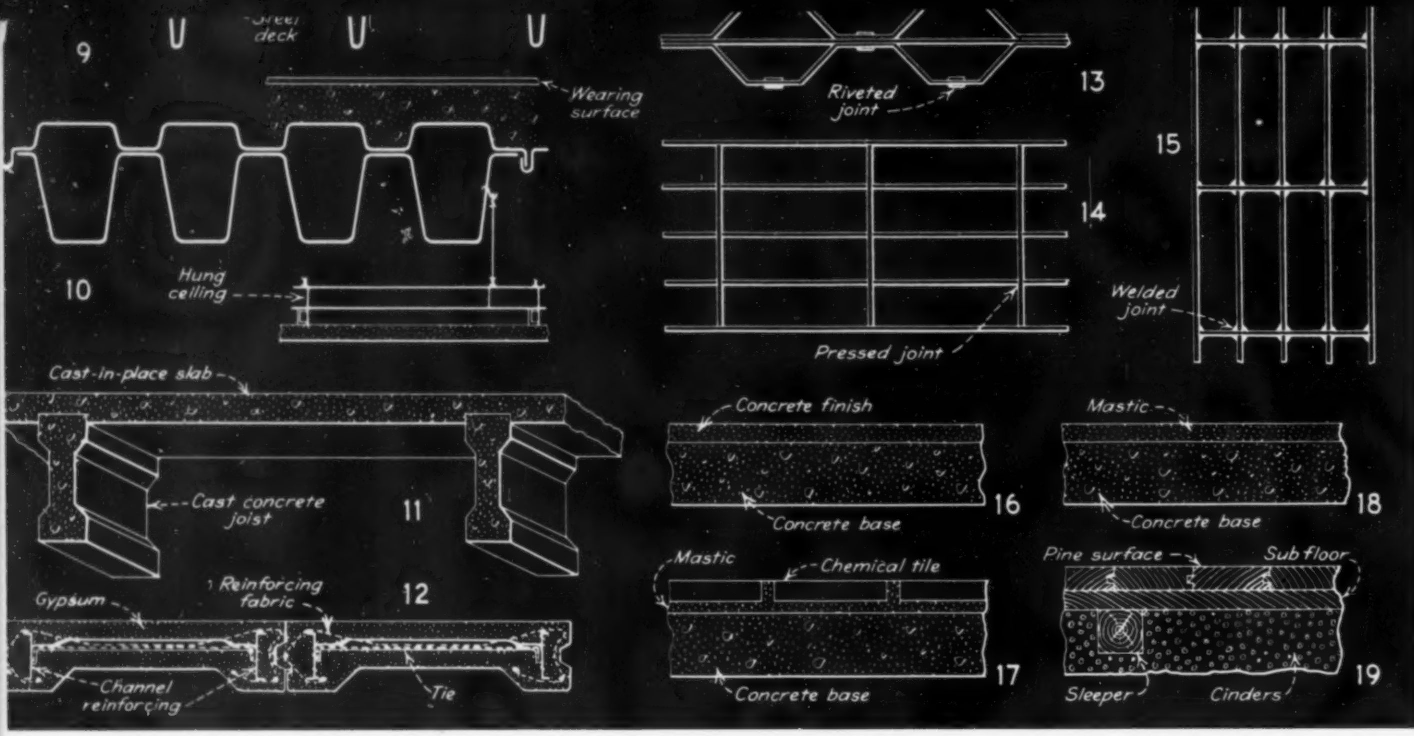
Because steel and concrete are very close together in coefficient of thermal expansion, a reinforced concrete structure is capable of developing the full strength of the steel. However, in order to prevent any possible slip of the steel in the concrete, various deformations of the steel are employed. One of the earliest was a simple twisted bar while some of the later types use protruberances. A patented reinforcing bar called "Isteg" (Fig. 4) is spreading in use. This is made by cold-twisting two bars together, like a two-strand rope, the process hardening the steel, showing up any inherent defects, and producing a shape which bonds excellently with the concrete. A considerable cost saving is claimed, the sum of several small savings, including a reduction of one-third in the amount of steel required.

Forms — Formwork for concrete has been cheapened by the use of sectional steel forms, which are by no means new, and by employing plywood or various composition boards in large sheets as a facing over rough lumber, which is a rather recent practice. If the plywood is oiled very little cement will adhere to it, so that the same form material can be used over and over and the resulting concrete surface will be practically as smooth as the plywood. This often makes any finishing work on the concrete unnecessary. The steel forms, even when oiled, do not produce a particularly good surface and should be used for concrete that will not be seen, or where appearance is of no importance.

Fireproofing—Concrete is doubtless the most frequently used material for the fireproofing of structural steel. Poured to a sufficient thickness around the steel members of a building it prevents the steel from reaching a temperature high enough

Figs. 1-8: (1) Fluted steel pile; (2) Concrete-filled steel tubes supporting a heavily loaded building column; (3) Showing how concrete is sometimes mushroomed from the bottom of a steel pile under pressure of a plunger; (4) Twisted-pair reinforcing bar for concrete (Isteg); (5) Light steel beam made by slitting and expanding; (6) Light steel beam fabricated by welding; (7) Nailer beam with wood nailing strip on top; (8) Stransteel beam which holds nails in the sinuous portion





Figs. 9-19: (9) Typical light steel floor or roof deck; (10) Robertson keystone-type cellular steel floor; (11) Pre-cast reinforced concrete joist for light construction; (12) Cross section of reinforced gypsum plank for floors or roofs (U. S. Gypsum Co.); (13) Riveted-joint steel floor or tread grating; (14) Steel floor grating assembled by pressure; (15) Welded non-slip steel floor grating; (16) Concrete-finished concrete floor; (17) Concrete floor topped with chemical tile; (18) Mastic floor laid over concrete; (19) Wood finish and underfloor laid on sleepers embedded in cinders

to cause it to drop its load in case of fire. General practice is to use a minimum of 1½ to 2 in. of concrete over horizontal members, such as girders, and 4 in. over vertical members, such as columns.

STRUCTURAL STEEL

Structural steel is available in a considerable number of well-known cross sections, such as angles, channels, T's, I-beams, H-beams, Z's and rods, all of which come in many sizes. Welding on the job, or in the shop fabrication of certain kinds of trusses, has resulted in the development of still other than the classical shapes. However, most of this is by no means new. Still, there are a number of less widely known developments that should be mentioned.

The open-web joist, formed either by slitting the web of an I-beam and expanding it (as in Fig. 5), or by welding separate parts together (Fig. 6), is a light-weight unit adequate in strength for many places. It has some minor advantages due to its open web, such as the freedom with which pipes and conduits may be strung through it, but its real reason for being is that it does its work with less steel than an I-beam contains. One form called a nailer joist, shown in Fig. 7, has a wood strip securely attached on top, for nailing.

An entire system of light steel-frame construction has been built up from the idea that it would be very convenient if one could only nail things directly to steel. The basis of this system is a unit similar to an I-beam but made of two light channels fastened back to back with a narrow space between them. The webs of the channels are bent into a wavy section, as in Fig. 8, the space between naturally following the same outline. When nails of the right diameter are driven into the spaces they are held more tightly than in wood, consequently anything that can be held with a nail can be fastened to the structural members, which are themselves held to each other by screws. Only a few main shapes and small attachments are necessary.

STRUCTURAL FLOORS

Floors in industrial buildings are generally of two parts, the sub-floor or structural floor, which takes the load, and the finish floor which is the wearing surface. The most frequent exception to this type of construction is the reinforced concrete floor, or concrete laid on the ground, which may serve both purposes with the same slab. However, even these types are often finished with some other floor surfacing material. When the structural floor is not of concrete, it is likely to be of steel, precast concrete or gypsum, or wood. Similar constructions are also used for roof decks.

Steel—If structural steel channels were to be laid side by side with the flanges down, one could build a fine roadway or bridge deck, but it would require a lot of steel. From this idea, a number of floor and roof systems have been devised, using light-gage steel sheets bent to various forms, instead of heavy channels.

Probably the simplest type is the corrugated sheet so often used for roofing, but sometimes serving as a form for concrete floor slabs. Used in this way it usually remains in place, becoming the finished ceiling, and, if spans are short, obviating the need of reinforcing the concrete.

The next step is to make the corrugations deep (Fig. 9), to obtain increased stiffness. A further development is to weld sheets to the corrugations, forming flat ceilings or floors or both. A considerable number of patented shapes are now on the market, each having some advantage in economy, speed of erection, or final results obtained.

Where the top surface of any such floor or roof system is flat it is apparent that certain finishes can be applied direct'y. When the corrugations or channels are open at the top, as in Fig. 10, concrete is used as a filler and fire proofer, and under such circumstances any depth of concrete and any sort of reinforcing can be employed that the spans and the loads require.

One company has developed an electric wiring system in connection with its steel floor construction, the hollow spaces in the floor serving as conduit. This permits outlets to be installed at almost any point in the

floor with minimum difficulty, either originally or as later extensions.

Precast Concrete—In some localities beams and slabs of concrete, properly reinforced, are being made for sale as a building materials as in Fig. 11. These are designed for short spans and light loads, so are not widely usable in factory construction. Where suitable, however, they provide a fire resistant floor that can be quickly finished, and require no derrick for handling.

Small slabs of special shape are made for roofs, being used to fill in between rafters and to serve as a foundation for some finish roofing material. Occasionally large slabs have been precast, to fill in wall areas. This system seems not to be generally applicable, but may solve a peculiar problem now and then.

Often pre-cast concrete slabs are made of concrete employing a light-weight aggregate, or a concrete "blown up" chemically during manufacture. Such slabs are much lighter than the ordinary product.

Gypsum Planks — A step away from precast concrete is the plank or slab of gypsum. Of various shapes and sizes they are 2 to 3 in. thick, dimensioned so as to be easily handled and laid, reinforced for strength, and with interlocking edges, as appears in Fig. 12. These may be laid on joists or rafters like wood lumber, serving as an underfloor or roof over which any type of finish material may be applied. They are incombustible, insulating, quickly installed, and weight less than half as much as concrete.

FLOOR SURFACES

If a perfect floor exists it has the following characteristics and probably others:

- Made from inexpensive materials;
- Cheaply installed;
- Immediately ready for use;
- Shock resistant;
- Abrasion resistant;
- Flexible;
- Not slippery under any condition;
- Noiseless and sound absorbing;
- Non-conductor of heat;
- Attractive to the eye;
- Numerous colors available;
- Unaffected by changes in temperature and humidity, or by oils, acids, alkalis, salts, solvents or water;
- Odorless;
- Germicidal;
- Easy to fasten machines, etc. to, and strong enough to hold them;
- Resilient enough to seem soft underfoot and to minimize damage to articles dropped on it;
- Will dissipate static electricity and is non-sparking when struck;
- Easily kept clean.

It is quite certain that no such ideal flooring material exists; in fact some of the qualities listed are contradictory in reality although one might conceive of a material that would possess them all.

As every flooring substance known to us will sooner or later wear out or may have to be replaced by another because of changes in work done, two other related characteristics are desirable: (1) Small repairs easily and quickly made; and (2) large sections easily and quickly removed and replaced.

No material will serve satisfactorily in all places so it is necessary to consider each space by itself and even, in some instances, to have more than one sort of flooring in a single area. So many factors affect a choice that it is best, after tentative selections have been made, to consult the makers of each material before final decisions have been reached so that, not only will the finish material be the best for the purpose, but the underfloor also will be just right, with proper allowances made for thicknesses, expansion, or whatever else may affect the finish floor itself.

Brick and Tile—Although concrete is probably used as the finish floor in more chemical plants than all other materials put together, concrete is not satisfactory under the most severe corrosive conditions. For the hardest service of this type, acid-proof brick and chemical stoneware tile usually prove to be the best types of finish, although also the most expensive. For such floors a concrete underfloor is generally used, to which the brick or tile is cemented with mastic, a sulphur cement, or one of the self-hardening acidproof cements.

Concrete—A concrete floor surface will be very much better than those commonly met if it is made according to the best practice. A careful selection of materials, the right proportioning, the use of the least amount of water that will wet the material, tamping, rolling, and compacting with a floor machine with a rotating steel disk, then a final going over with a steel trowel, will produce a surface that is dense, watertight, and wear-resisting to a remarkable degree. A period of "curing," during which the concrete is kept thoroughly wet, must follow, after which the floor is ready for the worst.

Quick-setting cement makes possible the use of new or patched floors in two days, so that week-end repairs are feasible.

To further harden the surface of concrete floors, metallic and other extremely hard aggregates are sometimes mixed in. The selection of the aggregate depends upon conditions to be encountered, so that the directions of the manufacturer should be carefully followed. This warning is even more important when chemical compounds are mixed with the concrete, as some are harmful.

Hardening treatments may be applied after the floor has dried, by floating a solution of magnesium fluosilicate, sodium silicate, aluminum sulphate, or zinc sulphate over the surface. Sometimes two or three successive treatments are used.

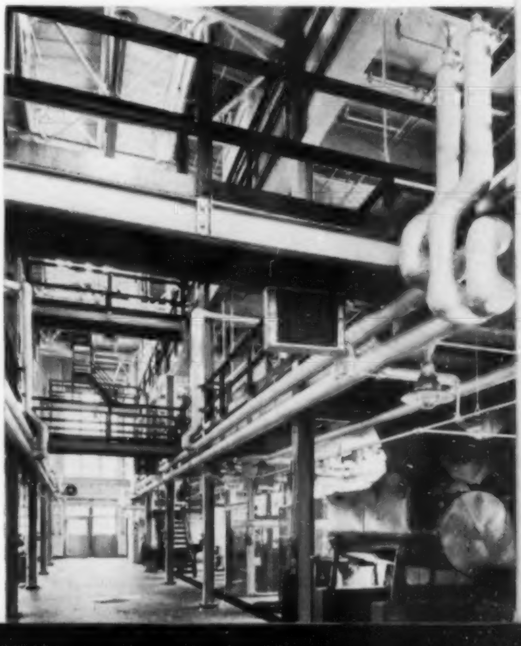
A treatment of warm linseed oil, China wood oil, or paraffin, applied so that it will soak in, prevents attacks by lactic acid, vinegar, salt, sugar and similar agents, although it is claimed that a very dense concrete will not be hurt by them.

Concrete floors that receive excessive punishment are reinforced with steel grids, which are generally rather light, the steel receiving the pounding while the concrete is mainly valuable as a filler. For very heavy work, cast iron grids may be used.

Terrazzo — Terrazzo is merely a concrete floor that has colored aggregate, usually marble chips, and that has been ground down until the color is exposed. It is suitable for lobbies, stairs and corridors in the administrative portion of a factory.

Non-Slip Concrete—Another material incorporated in concrete is finely divided abrasive, such as silicon carbide, to prevent slipping at dangerous places. This is mixed only in the finishing coat, or sprin-

Fig. 20—A good solution to the chemical plant floor problem is that shown below in a recent addition to the Eli Lilly plant; note mezzanines and cross-overs



kled on while the surface is still soft, and trowelled in.

Oxychloride Cement — Magnesium oxychloride cement has advantageous qualities which led to its wide use for floors and stuccos some years ago. It had one fault which causes its slow destruction: solubility in water. H. H. Robertson Co. has discovered that the addition of finely powdered copper to the cement alters its characteristics so that it is usable as a plastic flooring material with unique properties. Sold under the name of "Hubbellite" the material is claimed to have great wear resistance and resilience and to be unaffected by or highly resistant to water, natural mineral oils, cooking fats, sugars, food wastes and fire. It is nonsparking and will conduct away static electricity. Furthermore it is claimed to destroy certain of the bacteria, fungi and algae sometimes found in buildings, probably the most common being that which causes "athlete's foot."

Bituminous Floorings—These materials have more or less in common. They are, for example, surfacing materials only, dependent in part upon the underfloor for their effectiveness. Irregularities will usually show through, changes from any cause are likely to produce cracks in the surface, and dampness beneath may destroy the bond between the materials. They are in themselves waterproof, quiet, resilient and non-dusting.

All are soft enough to be damaged by heavy loads, especially when temperatures are high, although they vary in softness according to their composition and when properly selected for the location are satisfactory. All will withstand a great deal of wear and are easily replaced.

They are uniformly non-sparking and non-slippery, although the latter quality may be affected by maintenance methods and wear.

Asphalt is the basis of a number of types of flooring, including hot mastic, cold emulsion, thin tile and paving blocks.

Mastic—Hot asphaltic mastic is a mixture of asphalt and graded aggregate, spread while hot about an inch thick. The proportions of the mix and the technique of placing are as important as with portland cement concrete and should be directed by skilled men. Cold asphalt emulsions are mixed with portland cement and sand, sometimes with stone also. The underfloor is wetted, then a priming coat of emulsion is spread, followed by the mixture. Here, too, proportions and technique are important. This flooring is much used for patching concrete floors. Owing to their good degree of corrosion resistance mastic floors are widely used.

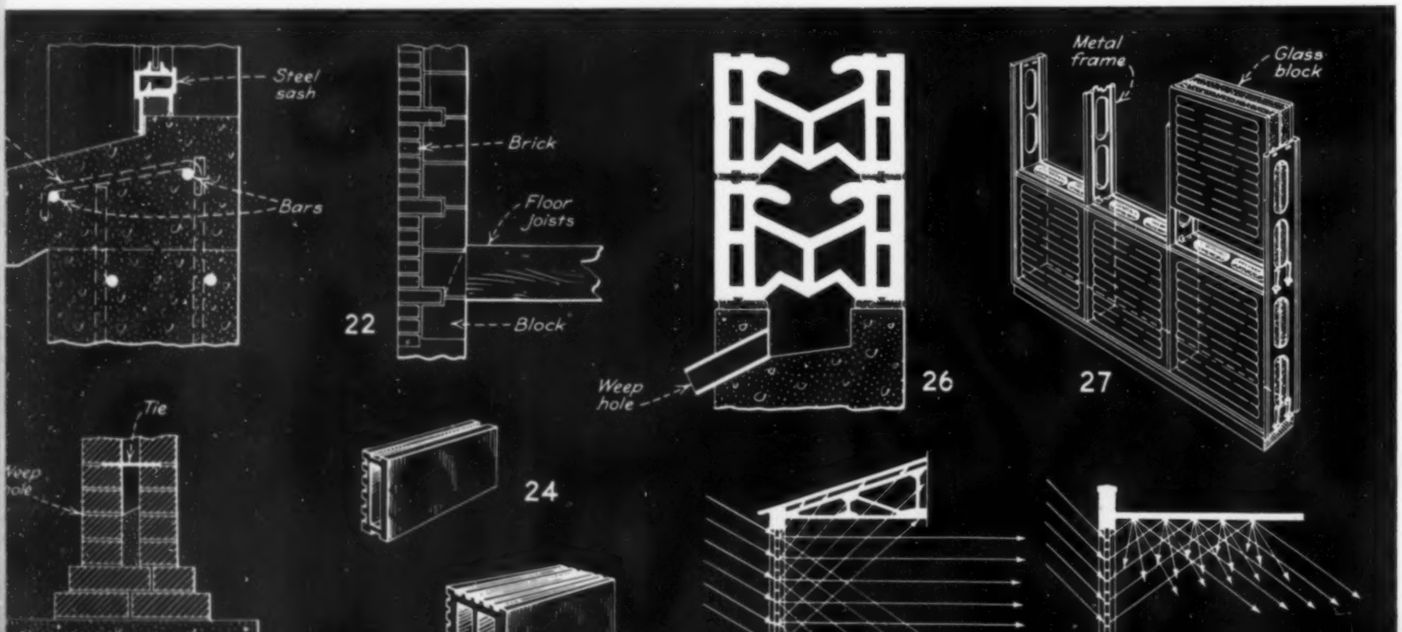
Both types of mastic require time for setting. To overcome that handicap, and to insure uniformity of product, numerous manufacturers are producing blocks and tile of asphaltic mixtures which can be used as soon as laid. Different compositions give somewhat different characteristics, especially in respect to hardness.

Tile and blocks are made in thickness from $\frac{1}{8}$ in., used where traffic is light, up to 3 in., for heavy trucking, as on roads and bridges. The thinner ones are cemented down with an asphalt paint or thin emulsion, the thick ones usually laid on a cement mortar base. Wherever decorative effects are important, as in offices, thin tile of various colors may be employed.

Metal Floors—In addition to its use as a sub-floor, steel also finds considerable use for the finished floor. Particularly is this true in the case of open steel flooring. Here grids somewhat similar to the type mentioned above for reinforcing concrete floors, of which Figs. 13-15 are typical, may be used for the entire floor, except for supporting beams, in working platforms, walkways, galleries, bridges, stairs, etc. They are lighter in weight than other types of construction which might be used, allow a considerable percentage of light and air to pass through, and are very easy to remove for repainting, hoisting materials, or for relocation of equipment, alterations or repairs that may be needed. A considerable number of patterns and methods of assembly are available.

Non-slip metal plates also have their uses. There are two types, one of rolled steel with a pattern of little raised studs or buttons, the other, various cast metals with abrasive grains in the surface. The first type is commonly used where there is trucking to be done or to cover hatchways and pipe channels. The abrasive type is excellent for stair treads and platforms and wherever a

Figs. 21-29: (21) Steel sash grouted into opening in concrete wall; (22) Brick wall bonded to block backing; (23) Brick cavity-wall construction gives a dry wall and maximum heat insulation for the material used; (24, 25) Two of many shapes of hollow terra-cotta units; (26) Natco terra-cotta unit for speedy erection and leak prevention; (27) Metal gridwork for mortarless erection of glass block interior partitions; (28) Diffusing type glass block used in a ceilingless building; (29) Prismatic glass blocks used to reflect from a ceiling; sometimes a combination of blocks is used



slip would be particularly dangerous. Frequently narrow strips of the latter type of material are cast in concrete at the edges of stair treads and platforms, both to take the excessive wear and to prevent slipping.

Wood—One type of wood floor that is being widely used is wood block. Made from several woods, usually yellow pine, in various sizes and depths, always with end grain exposed, these blocks can take a great amount of punishment. They are impregnated with creosote or other preservatives and cemented to a concrete underfloor with pitch which is also used to fill joints. They are used to a large extent in metal working industries and could probably be used more frequently to advantage in chemical plants.

Such blocks have many of the qualities listed above as inherent in the ideal flooring material, important among which is the ease with which machinery may be attached. The blocks will not pull up individually, as might be expected, as they are bound together in various ways in addition to being cemented in place.

There are sections in some plants where wood plank floors are adequate, or where wood covered with other materials such as mastic or linoleum may be the best treatment. It should be mentioned that there have been advances in floor finishes and that both wood and linoleum can be covered or impregnated with substances which greatly increase their permanence.

An important thing to be considered in connection with floors is whether there will be spillage of substances which, either alone or when mixed with wash water, will corrode the nearby structural steel. As steel, whether used for columns, beams, or concrete reinforcement, is commonly encased in a coating of cement mortar or in concrete—unless entirely exposed to view—it is in order to investigate the effects of the chemicals which may be spilled upon the cement. Some substances which may be safely stored in concrete tanks will nevertheless soak into a concrete floor which is subjected to the battering of truck wheels. Others are destructive in dilute form, as after washing, but safe when concentrated.

Common practice in chemical plants is to construct concrete floors and those covered with mastic like shallow pans with a raised edge or dam around all walls and columns. A further protection is to keep the floor about an inch or two clear of the columns, with an open air space between, and in extreme cases to fill the floor pan with earth to absorb the spillage.

Where conditions are bad one more step should be taken which is to have all steel painted during erection with a protective paint, usually asphaltic, and sometimes to paint the concrete floor in like manner.

WALLS

In an earlier day, factory walls not only had the function of inclosing the structure, but also of supporting the upper floors. Today, except in the case of reinforced concrete buildings walls are generally non-load-bearing, for the purpose of inclosure only. Thus, they ordinarily do not need to be very heavy and in the case of much factory construction are of light corrugated materials such as steel or asbestos-cement composition. Although masonry walls, particularly in single-story structures, may be made heavy enough for load bearing, the tendency toward large areas of window glass generally relegates these materials also to fill-in between the steel framing members. Masonry materials now used include cinder and cement blocks, brick and terra-cotta tile. A rather recent develeopment for the purpose is glass block.

Cement Blocks—Cinder blocks are lighter in weight than the so-called cement block, transmit less moisture although more porous, have better insulating value, and commonly are cheaper. They are not so strong, however, and are dark in color and rough, making them unsuitable for a finished wall in most places.

Cement blocks are made with stone or gravel and are much denser and hence stronger than cinder blocks. This type is light in color, smooth and accurate when well made, and can be obtained solid or with air spaces. Such blocks can be had shaped so as to bond with a brick facing (Fig. 22), producing a very good wall at moderate cost, one which may be left unfinished or painted on the inside.

Any solid masonry wall may leak, and probably every one will cause vapor to condense on its inner surface during cold weather, which should be given consideration when an exposed wall is contemplated.

Brick and Tile—A type of masonry wall designed to avoid leakage is the cavity wall of brick, an importation from Europe where considerable experience has demonstrated its value. This wall consists of two entirely distinct walls of brick fastened together by metal ties and separated by a 2-in. air space, as in Fig. 23. The air space is continuous all around the building and from top to bottom. For light bearing loads each wall may be a single brick in thickness; for others, however, the inner wall should be 8, 12 or even 16 in. according to height and the weight to be supported. The insulating value of the air space is said to be at least equal to that of another 4 in. of brick, while it obviously is an effective moisture stopper.

Fig. 30—Porcelain enameled steel siding is a recent development of Porcelain Enamel Steels, Inc., Cleveland. Roofing and architectural trim are also enameled

Some structures have been built with small openings from the basement into the air space, with other openings at the top. Gravity circulation of air was thus obtained. This would seem to be worth studying as a means of temperature control.

Terra-Cotta—Backing up a 4-in. brick wall with hollow units is another way to entrap air for its insulating value. Cinder and cement blocks were mentioned above, but an older and possibly more widely used material is the hollow terra-cotta load-bearing block. These blocks are used to a considerable extent in chemical plant construction owing to low cost and corrosion resistance. When laid up with a weak mortar, walls made from them may be taken down and salvaged when building changes are needed.

Terra-cotta blocks come in a considerable variety of shapes and finishes, of which Figs. 24 and 25 are only two types. Some are purely structural, intended to be bonded with brickwork, and having a channeled inner face to hold plaster. Others are glazed on the inside, and

another type constitutes a complete wall material in one piece, having both outer and inner surfaces which require no further treatment.

One ingeniously shaped hollow tile (Fig. 26) is said to save labor in laying because it is very easily held, and furthermore its interior webs form channels which will carry off water if there should chance to be leaky spots in the wall.

For inside use, base and corner tiles with coves and bullnoses are made, also cap tiles for the top of a wainscot or a low partition and a number of radial shapes. Both salt and ceramic glazes are used, as well as unglazed surfaces, providing a wide range of colors and effects for the designer. Perfected methods of manufacture and selection have eliminated most of the defects formerly common, so that a fine appearance can be obtained when this is important, or by using second or third grades, substantially the same results, except in looks, are possible at lower cost.

Wherever great load-bearing capacity is needed, standard-sized brick having the same finishes as the hollow tile can be used. With either brick or tile it is obvious that cleanliness can easily be maintained and only severest abuse will cause damage.

Glass Blocks—Although nowadays well-known, glass blocks are so suitable for use in many chemical plant applications that a listing of their qualities is in order.

Their primary purpose is to admit daylight through exterior walls, serving in lieu of sheet glass. They have also been used in saw-tooth skylights and in monitors for the same purpose. It is doubtful whether they are properly used in interior partitions, where the transmitted light is small and there are some disadvantages. There may occasionally be places where their decorative qualities warrant their use, but only rarely and in small numbers in a factory.

However, should interior glass blocks be desirable, a system of metal gridwork for erecting partitions (Fig. 27) has recently been put on the market, which permits easy demolition and re-use without waste.

It is obvious that glass blocks will not transmit as much light as the far thinner flat glass, but the light which does get through is well diffused and effective. Because of the diffusion, shadows are reduced. One type insures still greater diffusion through use of a thin glass fiber mat fused between the halves of the unit.

Several types are made which vary in their transmission of light. Such conditions as undue exposure to sun, reflecting ceilings, no ceilings, and deep rooms needing light far inside, are taken into account by the makers of the blocks. Figs. 28 and 29 suggest suitable methods for specific problems. A combination of blocks in a single wall is at times desirable, the lower rows diffusing the light for nearby workers the upper ones sending it far into the area or even against the ceiling.

Solar heat passing into the interior is reduced by as much as 65 percent with some types, and discomfort even more, as no direct rays reach workers. Heat loss from the interior is also reduced to an extent that permits almost an entire wall to be built of blocks with less loss than through a brick wall with about one-quarter of its area in windows. Condensation on the interior is much less than with ordinary windows, simplifying humidity control. No dust can enter through such wall panels; resistance to fire is high; sound insulation is good; cleaning is easy; and maintenance costs are negligible.

Fig. 31—Where large areas need good daylight the use of glass-block-walled monitors as in Industrial Rayon's new Painesville plant prove an excellent solution

WINDOWS

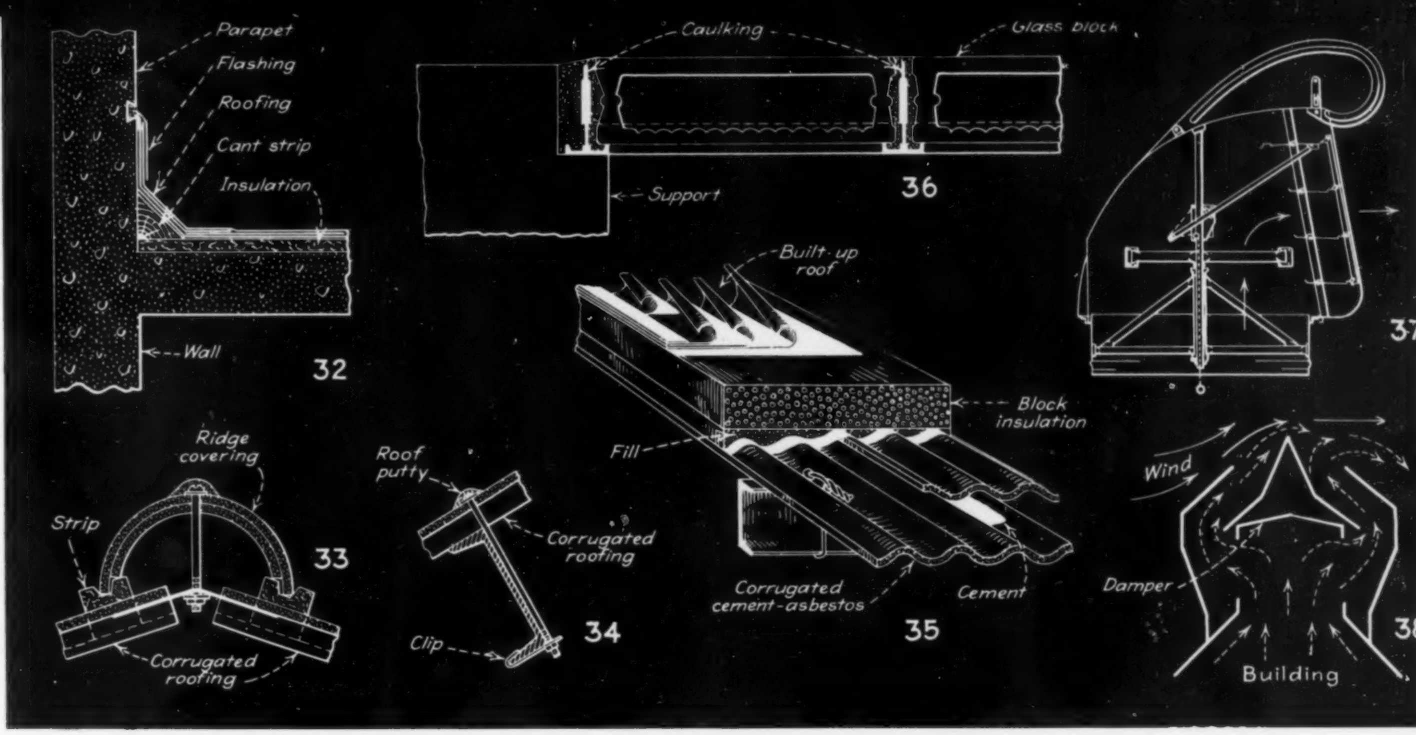
As compared with the small windows used in the old mill-type construction, modern factories have gone to extremely large areas of window glass. In some cases this has extended to the point of making most of the outer wall of glass by reducing the sizes of columns, mullions and muntins, in some cases even going to cantilever construction so that there are no columns in the line of the windows. However, in chemical plants, where such large expanses of glass are rarely needed, this trend has not been especially notable. Although steel sash is now largely used, there has been some tendency to return to wood sash on account of its better corrosion resistance. In plants having explosion hazards, light sash hinged to swing out easily for explosion venting are often used. Sometimes glass is scored with a diamond to insure its breaking in case of an explosion.

For some rooms certain of the special window or skylight glasses may be desirable. For example, actinic plate glass is now made that will absorb about 48 percent of the heat rays from the sun. About half of this amount, during warm weather, will find its way inside by radiation and convection, the other half will be dissipated outside. Another 5 percent of the heat is reflected by the exterior surface of the glass so that about 29 percent of the solar heat does not enter the building, whereas 78 percent of the visible light does. By double glazing, about half of the heat may be excluded.

A recent type of double glazing is accomplished by joining two sheets of glass with a metal seal which permanently retains about $\frac{1}{4}$ in. of dehydrated and dust-free air between. A considerable reduction in heat transmission is achieved, with marked lessening of condensation.

STAIRWAYS

Access from one floor to another in a building many be accomplished with either stairs or ramps, although the latter seem rarely to be used except where a considerable number of employees is involved, or materials handling is by truck. The minimum width of stairs to accommodate one person should not be less than 22 in., and where possible conflicts on the stairs may occur, the width should not be less than double this. Ramps should not be used where the grade is more than 20 deg., while for a grade of more than 50 deg., fixed ladders are properly employed. Factory stairs are usually not designed for the same degree of comfort as other stairs. However, considerations of safety must be kept in mind. For example, open risers should be avoided. The possibility of the foot slipping through can be minimized if a flange is provided at the back of the tread. The tread in no case should be less than 6 in., nor the rise more than 8 in. Many types of satisfactory construction may be employed. In the case of per-



Figs. 32-38: (32) Built-up roof on a concrete building; (33, 34) Ridge construction and roof support details for corrugated cement-asbestos roof (Johns-Manville); (35) Insulated non-condensing corrugated roof (Johns-Manville); (36) Inverted T-frame support for glass block roofs and floors; (37) Rotating ventilator; (38) Continuous-ridge-type ventilator

manent stairs, reinforced concrete may be used, or a steel frame with one of the numerous types of treads that are available. For less permanent stairs, as to working platforms, riveted, bolted or welded steel can be used, usually with treads of open-steel gridwork.

DOORS AND ROOFS

Numerous types of doors usually of steel, may be had for closing openings of almost any size. For truck entrances and shipping platforms, roll-up doors, tilt-up designs, and rolling grilles, any of which may be motor-operated, can be used. For fire doors in interior partitions, the most common construction is the gravity-operated type, with fusible-link release to permit closing in the event of fire. In this connection, it is worth noting that if the fire door is so heavy that it cannot be opened by one man, some other means of escape must be provided.

Except in rare cases, factory roofs which are nearly flat will be finished with a "built-up" surface applied over a solid backing (similar to the various underfloors described above), while those with a distinct slope will employ some corrugated sheet material, usually without any kind of backing or other support except the purlins. The same types of corrugated materials are often used for side walls.

Built-Up Roofs—The methods and materials employed in the making of built-up roofs (Figs. 32 and 35) are so well known that they need not be commented on extensively here. Suffice it to say that such roofs can be applied successfully to almost any kind of roof deck. The usual construction is to apply a minimum of three layers of impregnated felt to the roof, with liberal coatings of tar or other bituminous material, after which the final surface is protected with a layer of gravel imbedded in the last tar coating. Such roofs are commonly "bonded," that is, guaranteed for periods of 10, 15 or 20 years, depending on the construction. A fairly recent development is the use of one or two layers of rigid insulation between the structural roof and the waterproof finish. This has the double advantage of decreasing the heat loss and preventing roof condensation during cold weather.

Rather new is the use of ⅜-in. thick asphalt-impregnated insulating boards as a wearing surface on top of built-up roofs and decks. This material is also suitable for basement floor surfaces.

Corrugated Roofs—Corrugated materials used for roofing include sheet steel, cement-asbestos, porcelain-enameled steel and glass. For use where galvanized steel is undesirable, corrugated sheets with other protective coatings, asphaltic in nature, have been produced. Several different corrugations are available, and as many as three distinct protective coatings are successively applied on each sheet. Some of these protected metals have been in service for over 20 years without replacement, and have demonstrated great resistance to weather, water, chemicals, fire, and abrasion.

A newcomer in the roofing field is porcelain-enameled corrugated-steel sheet, shown being erected in Fig. 30. For some time this glass-like surfacing material fused to steel, has been used for signs, wall covering, and similar exterior features, so that its weathering capabilities are proved.

Corrugated sheets of asbestos and portland cement are too widely known and used to require description here. Long lived under corrosive conditions, they are extensively used in chemical plants. Details of ridge construction and a method of attaching the sheets to the purlins are shown in Figs. 33 and 34, and a method of insulating such roofs against condensation, in Fig. 35.

Wherever a great amount of natural daylight is imperative an entire roof can be covered with corrugated wire-glass. The corrugated form stiffens the glass so that clear spans of 5 ft. are quite safe, and the glass can be used without any metal frames such as are general in skylights. Metal channels with waterproof sealing strips are used to join the sheets. This glass is used on saw-tooth skylights and on vertical surfaces just as effectively as for roofing. It can be obtained in heat absorbing and glare reducing types.

All of these corrugated materials are held together and to the building, and made watertight at joints, by means of clips and other fasteners especially designed by the various manufacturers.

A new use for glass blocks employs a slightly different form developed for flat and sloping surfaces, such as

roofs, skylights and floors. A system of support for the blocks, using inverted T-shaped metal members, and a synthetic rubber sealing compound, is said to insure a strong and watertight panel with insulating and other characteristics about the same as for wall panels. The method of support appears in Fig. 36.

CAULKING COMPOUNDS

A variety of caulking compounds has been developed because putty has too many shortcomings. Such compounds have become specialized so that they are available in different colors and consistencies and particularly adapted to different purposes. Their chief use is for sealing joints, as in glazing and between window and door frames and the surrounding wall, especially if the wall is of masonry. Other applications are between roofs and skylights, roofs and chimneys, and roofs and projecting pipes. They may be used to fill cracks and joints in masonry, especially those that are badly exposed as are the joints between coping stones, and they are sometimes trowelled or brushed over an entire wall surface. Owing to superior adhesiveness they are ideal materials for holding structural glass against a backing. The main characteristics of a good caulking material which make it valuable are its adhesiveness, its waterproofness, and its permanent elasticity.

It is not always realized how much infiltration of air there may be into a building, bringing in dust and discharging an equivalent amount of inside air. Careful caulking of openings around window and door frames and in less obvious places will greatly reduce this exchange of air and ease the load on the heating or air conditioning plant.

VENTILATION

The air conditioning of a plant is a matter for expert study in each case, involving consideration of heating, cooling, dust removal, circulation, humidity modification, and the removal of fumes and of contaminated air. In many places, during at least half the year, natural circulation will accomplish all that is necessary, if properly designed.

When air is admitted at a low level in a space, usually by opening windows at the sill level, and is allowed to escape at the highest point of the roof, a gravity-induced circulation is obtained that will lower temperatures and contribute to comfort. Often the free escape of the air is thwarted, however, because the highest opening is some distance below the top, or is so shaped that air must travel downward to get out. Many pivoted and bottom-hinged windows are installed close to ceilings and roofs. To keep rain out, these open inward at the top. Air does not move freely out of such windows, but must be pushed out. Hence, a pocket of hot air in such cases tends to stagnate immediately under the sun-heated roof, to some extent reducing the movement of all air below.

Effective ventilators for roof tops are available, designed to obviate such difficulties. The simplest is a chimney-like flue, sometimes entirely open at the top, usually of material resistant to corrosion, and used where heat is sufficient to create a good draft. Various metals, cement-asbestos, and coated or impregnated wood may be used. Several such ducts may be gathered into one, each removing fumes from its own area.

Hoods may be placed over such vents, varying from the simplest cap intended for shedding rain, to a rather elaborate combination of parts devised to permit gases to escape, whatever the wind or weather conditions, while keeping the water out. The next step is to pivot the hood, as in Fig. 37, so that it can revolve. Ball bearings and a vane insure that the hood will always point downwind to provide maximum aspirating effect. For higher air velocities a horizontal fan may be hung in the base of ventilators of this type.

Another type of ventilator (Fig. 38) extends the entire length of a roof, usually along the ridge of a pitched roof. The best ventilators of this type permit no rain to enter the building, yet do not obstruct the flow of air, and are shaped so that wind increases the flow rate. They can be had with manually or electrically operated dampers and also with thermostatic control.

SOUND AND THERMAL INSULATION

The ultimate factory may well be almost noiseless. Today, however, there is usually plenty of noise, wearing on the nerves and, to some extent, destructive of efficiency. In most plants there are noises which are avoidable, and others which can be absorbed, so that the total noise burden can be considerably lessened.

In many cases noise can be diminished at little or no cost merely by selecting materials for construction that tend to absorb and deaden sound rather than to transmit or reflect it.

A so-called "acoustic" material on walls and ceiling, such as a sound-absorbing instead of a dense, reflecting plaster, or a sound-deadening tile, will do much toward reducing fatigue in an office or other constantly used room. A porous type of insulating board can often be used as a finishing material with the same result. Noiseless floors will also help.

Noisy sections in a plant may also be walled off from the remainder so that very little sound gets through. A double wall with sound deadening material between is one way; another is to hold the plaster away from the wall, on one side, by what is called a "floating" construction. Occasionally minor partitions used to subdivide a large space can be finished with insulating board instead of a denser material.

Another phase of sound control, and one that is necessary if heavy machinery is to be silenced, is vibration isolation. In the case of lighter machinery, mechanical and rubber springs are being used for the purpose, as well as cork and felt pads. For large equipment such as heavy ball mills, it is now possible to isolate the vibration entirely by "floating" the entire foundation on cork or felt. This subject is a highly specialized one at present and satisfactory results can be assured only through expert advice.

In a general way the same structural materials which absorb and deaden air-borne sound are good heat insulators. There are three main classes of thermal insulating materials in use for construction: reflecting (metal foil), bulk materials (mineral wool, granulated cork, mica pellets, glass wool, sawdust), and sheets and blocks (plaster and fiber boards, cork and molded impregnated mineral wool). The last two are the types generally employed in the insulation of refrigerated spaces since they can be effectively waterproofed against the penetration of moisture.

In some sections of some factories constant temperatures are of paramount importance, or non-condensing roofs may be required, and the methods of insulation determined upon will dictate the construction of the building. In most spaces, however, special insulation is not given much thought, it being assumed that ventilation will do away with too much heat, while exhaust steam or waste process heat will supply any that is lacking. Perhaps the advantages of such barriers against heat passage should be more often studied in plant design, both for improvement in year-around comfort and for economy of heat.

Plant Location Bibliography

In August 1934 (pp. 439-442), *Chem. & Met.* published "A New Bibliography of Plant Location," by J. H. Perry and C. W. Cuno. The list given herewith covers the intervening years and brings the subject up-to-date. It is a part of the discussion of plant location which appears on pp. 80-89 of this report.

A

Adapting Products to Local Markets; A. R. Maas Chemical Company, Los Angeles. F. C. Bowman, *Chem. & Met. Eng.*, **41**, 72–3, Feb., 1934.

Adequate Transportation Increases Potential Market; Mathieson Alkali Works, Lake Charles, La. *Chem. & Met. Eng.*, **42**, 258–9, May, 1935.

Alfred Weber's Theory of the Location of Industries. 256 pp. Univ. of Chicago Press. 1929.

America Reborn; A Plan for Decentralization of Industry. R. L. Woods, 376 pp. Longmans, 1939.

Automobile Steel and Geography. W. Trinks, *Blast F. & Steel Pl.*, **22**, 587, Oct., 1934.

B

Big Idea Behind Those Small Plants of Ford's, A. Van Vlissingen, *Factory Management*, **96**, 46–50, April, 1938.

Business and Government. *Fortune*, **17**, 67–70, March, 63–4, April, 1938.

C

Chamber of Commerce of the United States Against Extraordinary Inducements to Promote New Plants. *Rock Products*, **34**, 79, Dec. 5, 1931.

Chemical Engineer and Industrial Planning. A. Gibb, *Chem. & Ind.*, **56**, 440–3, May 8, 1937.

Chemical Industry and the Forty Eight States. C. Penrose, *Chem. Ind.*, **41**, 129–30, Aug., 1937.

Chemical Munitions Plants; A Lesson In Economic Geography. A. R. Ginsburgh, *Chem & Met. Eng.*, **47**, 768–9, Nov., 1940.

Choice of Factory Sites; Facilities Offered by Sites Adjacent to Railways, *Chem. Age* (Lond.), **25**, 470–1, Nov. 28, 1931.

Choice of a Factory Site; The Extent to Which Electrical Supply Enters Into the Problem. H. L. Farmer, *Elec. R.* (Lond.), **110**, 874, June 17, 1932.

Choosing a Factory Site. *Mech. Handling*, **19**, 33–4, Jan., 1932.

Cities Move to Escape Floods; Hill, N. H., Shawneetown, Ill., Leavenworth, Ind., Greenville, Mo., *Eng. N.*, **124**, 370, March 14, 1940.

Clearing May Build; Has 100% Occupancy. *Business Week*, p. 36–7, April 30, 1938.

Company and Community Relations. C. S. Slocombe, *Personnel J.*, **18**, 203–10, Dec., 1939.

Company Gets Better Plant Location. F. H. Leonhardt, *Food Ind.*, **8**, 298, June, 1936.

Contrast of Methods Used In Securing Industries; Duke Power Company and T.V.A. E. S. Grayson, *Public Serv. M.*, **58**, 113–5, April, 1935.

D

Decentralizing For Flexibility. J. A. Murphy, *Am. Business*, **7**, 29–30, 32, June, 1937.

Decentralizing To Reach Markets. J. A. Murphy, *Am. Business*, **7**, 15–16, April, 1937.

Decentralization of Industry. W. J. Cameron, *Mech. Eng.*, **59**, 483–7, July, 1937. Abstracts in *Iron Age*, **139**, 76, May 27, 1937; *Steel*, **100**, 56, May 31, 1937.

Decentralizing to Reach Markets. J. A. Murphy, *Am. Business*, **7**, 15–16, April, 1937.

Design of Industrial Buildings. S. Papadaki, *Arch. Rec.*, **81**, BT 7, Feb., 1937.

Difficulties of Industrial Decentralization. *Pub. Util.*, **16**, 508–9, Oct. 10, 1935.

Diversification Goes South; States and Cities Offer Inducements. *Business Week*, p. 20, 23–5, Feb. 12, 1938.

Do We Have to Move South? Asks the Wool Industry. *Textile World*, **85**, 1828–9, Sept., 1935.

Doctor for Sick Cities; Hetz Remodels Unneeded Plants and Sells to Young Concerns. G. R. Reiss, *Nation's Business*, **28**, 27–9+, Aug., 1940.

E

Easy Way to Determine the Center of Distribution; Truck-leasing Company. K. B. Keefer, *Food Ind.*, **6**, 450–1, Oct., 1934.

Economic and Technical Factors in Chemical Plant Location. J. H. Perry and C. W. Cuno, *Chem. & Met. Eng.*, **41**, 434–8, Aug., 1934.

Economic Factors in Chemical Plant Location. Section 26, Chemical Engineers' Handbook, 2nd Edition, 1941. McGraw-Hill Book Co., New York, N. Y.

Economics of Plant Location. C. H. H. Weikel, *Manuf. Rec.*, **101**, 18–19, March 31, 1932.

Effects of the Rationalization of Industry on Industrial Distribution. J. H. Haws, *Inst. E. E. J.*, **82**, 78–83, Jan., 1938.

F

Factory Advertisement; New Plant of Kitchen Art Foods, *Ptr. Ink*, **169**, 93, Oct. 4, 1934.

Factory Planning, H. Gutteridge, *Engineering*, **139**, 51, Jan. 11, 1935.

Factory Sites. *J. Soc. Chem. Ind.*, **50**, Supp. S, 1–14, Nov. 27, 1931.

Flight of Industry; New England's Industrial Migration Due to Code, Labor, and Tax Troubles. *Business Week*, 9–10, Feb. 2, 1935.

Ford Champions the Small Plant. B. Finney, *Iron Age*, **131**, 695–7, May 4, 1933.

Ford Decentralizes; Manufacturing Valves at the Northville Plant. B. Finney, *Am. Mach.*, **81**, 320–2, April 21, 1937.

Future Growth of American Cities. C. A. Dykstra, Am. Water Works Assn. J., **27**, 1041–8, Aug., 1935.

G

Geography of Steel; Factors Governing Location of Main Producing Areas. C. E. Wright, *Annalist*, **49**, 766–7, May 14, 1937.

G. M. and Ford are Moving Out. *Business Week*, p. 16–17, April 3, 1937.

Going South? G. W. Taylor, *Textile World*, **86**, 867–8, April, 1936.

Great Lakes Steel Corporation Now Operating. *Blast Furnace & Steel Plant*, **18**, 1817–23, Dec., 1930; *Steel*, **87**, 43–6, Nov. 20, 1930; *Iron Age*, **126**, 1606–10, Nov. 27, 1930.

Great Shifts of Industry in Progress. P. Field, *Mag. of Wall St.*, **59**, 814–17, **60**, 15–17, April 10–24, 1937.

H

How One Company Chose a Home; International Nickel Plant at Huntington, W. Va. *Nation's Business*, **22**, 78–9, May, 1934.

How to Attract Industries; Efforts in Paterson, New Jersey. H. S. Swan, *Banking*, **31**, 30, Feb., 1939.

How to Make Money Make More Money Through Plant Location. A. L. Scott, *Textile World*, **90**, 104–5, Feb., 1940.

How to Promote Community and Industrial Development. F. H. McDonald, 260 pp. Harper. 1938.

I

Important Automotive Industrial Center Developing in New Jersey, *Steel*, **101**, 26, July 12, 1937.

In Black and White; The Facts Concerning Industrial Advantages in Massachusetts. 75 pp. Massachusetts Development and Industrial Commission, Boston, 1937.

In Union There is Strength, High Point, N. C. Chose Its Industries. W. L. Hammer, *Nation's Business*, **23**, 39–41, Nov., 1935.

Industrial Districts of the Chicago Region and Their Influence on Plant Location. W. N. Mitchell and M. J. Jucius. *J. of Business*, **6**, 139–56, April, 1933.

Industrial Location; Reports of the Royal Commission on the Geographical Distribution of the Industrial Population. *Economist*, **138**, 196, Feb. 3, 1940.

Industrial Location and the Housing Market, E. M. Hoover, Jr. Ann. Am. Acad. **190**, 138–44, March, 1937.

Industry and Agriculture in the Tennessee Valley; A Mutually Complementary Development as a Basis for a Stable Civilization. W. R. Woolrich and J. P. Ferris, *Mech. Eng.*, **56**, 195–202, April, 1934.

Industry is Decentralizing; Pictograph. *Sales Management*, **44**, 41, June 15, 1939.

Industry on the Move; Survey of Migration, Decentralization, New Competition. *Business Week*, pp. 44–52, Feb. 27, 1937.

Is a New Plant Location the Way Out? J. A. Piquet. *Iron Age*, **129**, 1385–7, June 30, 1932; *Ptr. Ink Mo.*, **25**, 46, Sept., 1932.

Is Decentralization Industry's Next Step? J. Geschelin. *Automotive Ind.*, **68**, 584–5, May 13, 1933.

Is Industry Concentrating in New Areas? G. C. Smith, *Nation's Business*, **26**, 24–6, Nov., 1938.

Is Industry Decentralizing? D. B. Creamer, 105 pp. Univ. of Penna. Press. Phila., 1935. Abstract: *Monthly Labor R.*, **41**, 1212–13, Nov., 1935.

Is Mass Production Doomed? T. MacManus. *Adv. & Sell.*, **20**, 13–14, Dec. 8, 1932.

Is the Small Rural Plant Practical for Mass Production? Henry Ford Answers in the Affirmative. C. O. Herb. *Mach.*, **43**, 637–9, June, 1937.

Is Your Plant Ready for Recovery? H. K. Ferguson. *Chem. & Met. Eng.*, **40**, 575–8, Nov., 1933.

L

Labor and the Shut-down of the Amoskeag Textile Mills. D. Creamer and C. W. Coulter, 342 pp. Work Projects Administration, Washington, D. C., 1939. Review: *Monthly Labor R.*, **50**, 1380–4, June 1940.

Labor Boomerang in Akron; Industrial Strife Cause of Removal of Rubber Factories. C. B. Coates, *Factory Management*, **96**, 38–44, July, 1938.

Latex Aids Decentralization of American Rubber Industry. G. D. Kratz, *Rubber Age*, **43**, 361–2, Sept., 1938.

Location of Industries and the Plight of the Depressed Areas, *Economist,* **125**, 347–8, 351, Nov. 21, 1936.
Location of Industry and the Depressed Areas. S. R. Dennison. 216 pp. Oxford, 1940. Review: *Mech. Eng.,* **62**, 903–4, Dec., 1940.
Location of Industry: Political and Economic Planning Survey, *Economist,* **134**, 489–90, March 11, 1939.
Location of Manufactures, 1899–1929, 67 pp. U. S. Census Bureau, Washington, 1933.
Location of Manufactures as Affecting Employment Opportunities. *Monthly Labor R.,* **38**, 795–7, April, 1934.
Location of Manufactures in the United States, 1899–1929. F. B. Garver, F. M. Boddy and A. J. Nixon. Bull. 6, 105 pp. Univ. of Minn. Employment Stabilization Research Institute, 1934.
Location Theory and the Shoe and Leather Industries. E. M. Hoover, Jr. 323 pp. Harvard Univ. Press., 1937.

M

Measurement of Industrial Localization; Development of Tools of Analysis. E. M. Hoover, Jr. *R. Econ. Statistics,* **18**, 162–71, Nov., 1936.
Money-Making Locations for Small Industries. J. A. Piquet. *Iron Age,* **130**, 871–3, Dec. 8, 1932.
Move to Market Pays Despite Old Rule; New Mill of the Newton Steel Co. *Business Week,* p. 10, Nov. 27, 1929.
Moving to the Country; Bendix Aviation Corporation Builds Plant on New Jersey Meadows. *Eng. N.,* **119**, 953–5, Dec. 9, 1937.
Mr. Ford Takes a Glimpse Into the Future. *Comm. & Fin.,* **22**, 145, Feb. 8, 1933.

N

Nearly Half of Steelmaking Capacity Is Concentrated in Four Counties. *Steel,* **99**, 21, Dec. 21, 1936.
New Bibliography of Plant Location. J. H. Perry and C. W. Cuno, *Chem. & Met. Eng.,* **41**, 439–42, Aug., 1934.
New Jersey Bids for Industry; No Income Levies, But Relatively High Property Taxes. J. D. Kelly, *Barron's,* **18**, 8, March 14, 1938.
New Orleans As a Manufacturing Center for the Rubber Industry. *Rubber Age,* **40**, 222, Jan. 1937.
New Plants for New Products. J. A. Murphy, *Am. Business,* **7**, 28–30, Oct., 1937.
New Plants—Where and Why; Nine Big Cities Report 619 New Firms. *Business Week,* p. 20, April 5, 1933.
New Techniques Meet Changed Conditions Economically; One-story Plants in the Country. H. K. Ferguson, *Arch. Rec.,* **89**, 146–7, Jan., 1941.
New Way To Get Factories; Elmira Industries, Inc. O. Monrad, *Nation's Business,* **23**, 48–9, Jan., 1935.

P

Pacific Coast Transportation Favors Plant Location. H. M. Remington and R. B. Koeber, *Chem. & Met. Eng.,* **42**, 452–3, Aug., 1935.
Part of Marquette's Capacity May be Shifted South, *Concrete* (mill section), **44**, 37, July, 1936.
Pattern of Industry in Britain, *Economist,* **138**, 49–50, Jan. 13, 1940.
Plant Location. C. W. Cuno, *Ind. Eng. Chem.,* **28**, sup. 108, 111, Nov., 1936.
Plant Transfer Brings Economic Advantages; Penn Electric Switch Co., *Steel,* **101**, 64, Nov. 22, 1937.
Problems of Industrial Planning. H. Beaver, *Engineer,* **166**, 511, Nov. 4, 1938.

R

Recommendation for Relocation of Industrial Population of Great Britain. *Monthly Labor R.,* **50**, 1124–7, May, 1940.
Refrigeration and Readjustment In the Tennessee Valley. W. R. Woolrich, *Refrig. Eng.,* **29**, 13–15, Jan., 1935.
Relocation of Industry; the Effect of Artificial Burdens on Migration. *Index,* **17**, 171, 174–7, Aug., 1937.
Report on the Location of Industry; A Survey of Present Trends in Great Britain Affecting Industrial Location and Regional Economic Development With Proposals for Future Policy. 323 pp. 10s, 6d. Political and Economic Planning, London, 1939.
Requisites for a Good Plant Location; Pictograph. *Sales Management,* **47**, 50, Nov. 15, 1940.
Rural Industrial Developments Open New Markets for Gas. W. Alwyn-Schmidt, *Gas Age,* **73**, 383–5, April 21, 1934.
Rural Industrial Location Cushions Shock of Depression; American Fork & Hoe Co., Wallingford, Vt. R. C. Taft, *Iron Age,* **135**, 32–3, May 16, 1935.

Reprints of this 48-page report are available at 50 cents per copy. Address the Editorial Department, Chem. & Met., 330 W. 42d St., New York, N. Y.

S

Selecting the Site for a Factory. J. H. West, *Chem. Age* (Lond.) **36**, 231, March 13, 1937; *Chem. Ind.* **40**, 369, April, 1937.
Selection of a Factory Site. P. Dawson, *Engineer,* **159**, 100–1, Jan. 25, 1935.
Significance of Location Upon Production Costs. J. L. Warner, Am. Inst. Engrs., *Trans.,* **32**, 193–220, June, 1936.
Sites for Factories. *Electrician,* **107**, 751, Nov. 27, 1931.
Small Rural Factories Can Weather Depressions. C. B. Sherman, *Manuf. Record,* **103**, 22–3, May, 1934.
Small-town Expansion is the Goal of a Danville, Ill., Five-year Plan; A Standardized Factory and Easy Financing Terms Lure Industry. *Arch. Forum,* **69**, 413, Nov. 1938.
Small Town Industries. F. W. Preston, *Glass Ind.* **14**, 110. Oct. 1933.
Some Advantages of a Rural Community from the Personal Relations Standpoint; Experiences of American Fork & Hoe Co. in Wallingford, Vt. R. C. Taft, *Iron Age,* **140**, 41–2, Aug. 19, 1937.
Some of the Factors Influencing the Selection of Mill Sites in the South. D. G. Moon, *Paper Tr. J.* **109**, 40–2, Sept. 21, 1939.
Some Site-Selection Factors for the Architect's Working Files. D. C. Roper et al. *Arch. Rec.* **82**, 102–6, Aug. 1937.
Sonotone Moves to the Country; Improves Production and Sales. E. W. Davidson, *Sales Management,* **42**, 49–50, Feb. 15, 1938.
Sources of Information on Plant Location. H. R. Parker, *Chem. & Met. Eng.,* **39**, 142–3, March 1932.
Special Areas and the Activities of Scottish Industrial Estates, Ltd. S. Bilsland, *Chem. Age* (Lond.), **38**, 89, Jan. 29, 1938.
States Vie in Tax Exemption, *Business Week,* March 27, 1937.
Staying In St. Louis; Emerson Electric Manufacturing Company Thanks C. I. O. Unit for Offer of $100,000 Loan. *Business Week,* pp. 35–6, March 16, 1940.
Steel Mills In Detroit Base Sales on Time Savings. H. F. Baker, *Automotive Ind.,* **63**, 362–5, Sept. 13, 1930.
Strategic Retreat; France Starts Moving Industries Away From Paris. *Business Week,* 24 pp., Aug. 24, 1935.
Strategy in Industrial Location; Economics, Social and Military Considerations. E. G. Mears, *Harvard Business R.* **17**, No. 1, 9–14, Oct. 1938.

T

Tax Bait for Industry; Survey Shows 23 States Granting Immunities in Effort To Lure or Hold Factories. *Business Week,* p. 22, Oct. 7, 1939.
They Bought to Save; Plant Concentrated, Equipment Renewed, Methods Revamped; Apex Electrical Manufacturing Company of Cleveland. L. Church, *Factory Management,* **92**, 256–7, June, 1934.
This Increase In Small Plants Looks Like Decentralization. *Business Week,* p. 22, May 25, 1932.
To a Manufacturer Seeking A Safe Spot for a War Materials Plant. J. Collins, *Annalist,* **56**, 236–6, Aug. 22, 1940.
Town That Wouldn't Admit Defeat; How New Industries Were Attracted to Scottdale, Pa., F. McQuillin, *Nation's Business,* **27**, 32, 34+, Nov. 1939.
Trends In Industrial Location In the Chicago Region Since 1920. W. N. Mitchell, *J. of Business,* **6**, 1–76, part 2, Oct. 1933.
Tubize-Chatillon Production Capacity Increased to 20,000,000 Pounds for 1938. *Rayon,* **18**, 821–2, Dec. 1937.
Twenty Years of Decentralization by the Ford Motor Company Has Brought Out Many Important Social Changes. W. J. Cameron, *Automotive Ind.,* **79**, 235–6, Aug. 20, 1938.

U

Urban Growth and Garden Cities. *Economist,* **130**, 487–8, March 5, 1938.

V

Vision in Kilowatts. S. Chase, *Fortune,* **7**, 34–6, April, 1933.

W

War Department Sees Need for Decentralization of U. S. Plants. *Iron Age,* **144**, 75, Nov. 2, 1939.
We're Not Paternalistic, but, Make the Plant a Place Men Like to Work In; Superior Tube Company, Collegeville, Pa. S. L. Gabel, *Factory Management,* **93**, 467–8, Nov. 1935.
What To Consider Before Relocating A Plant. R. M. Fischer, *Iron Age,* **129**, 1007–9, May 5, 1932.
When A Community Offers to Finance a Business. J. A. Murphy, *Am. Business,* **8**, 14–16, April, 1938.
When Industry Decentralizes. D. C. Roper, *Factory Management,* **93**, 143–4, April, 1935.
Where New Defense Plants Will be Built, and Why. A. R. Ginsburgh, *Factory Management,* **98**, 42–6, Sept., 1940; Excerpts, *Management R.* **29**, 367–9, Oct. 1940.
Where Shall We Build? G. C. Smith, *Factory Management,* **96**, B 39–43, April, 1938.
Where Should Your New Plant Be Built? Aviation, **39**, 55, 120+, Aug. 1940.
Where To Locate the Plant. C. P. Wood, *Factory Management* **95**, 46–9 part 2, April, 1937.
Why Business Is Decentralizing. E. Whitmore, *Am. Business,* **7**, 11–13, March, 1937.
Why Locate in New England? J. W. Hook, *Am. Mach.,* **82**, 215, March 23, 1938.
Why These New Chemical Industries Went South; Six Case Studies in Plant Location. S. D. Kirkpatrick, *Chem. & Met. Eng.* **41**, 400–13, Aug. 1934.
Workshop Organization and Management; Selection of Works Site. E. T. Elbourne, *Engineering,* **139**, 288–9, March 15, 1935.

Y

Yankee Metal Products Corporation Moved to Another City. J. M. Robins, *Factory Management,* **98**, 60–1, June, 1940.

THE COMMITTEE OF AWARD

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ANNOUNCING NEW PLANS FOR Chemical Engineering AWARD

The fifth in a series of biennial awards sponsored by *Chemical & Metallurgical Engineering* to encourage group effort and achievement in the process industries is to be decided by the heads of chemical engineering in approximately 40 educational institutions that have been accredited by the American Institute of Chemical Engineers and the Engineers' Council for Professional Development. Announcement of the winning company will be made in October and presentation of the award during the Chemical Exposition in New York in December. Committee will welcome suggestions from all *Chem. & Met.* readers.

EIGHT YEARS AGO when plans were first announced for an award for chemical engineering achievement, two objectives were uppermost in the minds of its sponsors. First was to recognize outstanding group effort and achievement in the process industries. Second was to advance the chemical engineering profession by encouraging a broader participation of its members in all the affairs of industry. Both are still prime considerations, but this year it is hoped that even greater emphasis can be placed on the professional aspect. What company during the past two years has done the most to advance the chemical engineering profession?

This is the question that the readers and editors of *Chem. & Met.* are putting up to this year's committee of award. And to make sure that that decision comes from no small group of hand-picked industrialists, we propose to go back of the fountain-heads of chemical engineering in this country—to the leaders of chemical engineering education in all the institutions that have been accredited by the American Institute of Chemical Engineers and the Engineers' Council for Professional Development. Thus we greatly broaden our base. We get a better geographical representation. More important, we benefit by the unselfish viewpoint of these men who are devoting their entire careers to the advance of chemical engineering as a profession.

What are some of the criteria to guide the committee in selecting the

company to receive the 1941 award? First of all, it seems to us, should be the company's attitude toward its technical men—more particularly, toward its chemical engineering personnel. Whether it employs few or many chemical engineers is perhaps less important than knowing how it uses them. Are they encouraged to participate in all the affairs of the company—in management and administration, in production and sales, as well as in the purely technical phases of research and development, design, construction and operation? Are technical men given fullest opportunity to grow and develop in their profession—to participate actively in its organized work, to share the burden of its committees, to attend its meetings, to contribute papers and discussions that add to the sum total of recorded knowledge of chemical engineering? What is the company's attitude toward research? Toward education, both in supporting the colleges and universities and in providing courses for "training-within-industry"? What has it done in the present emergency to mobilize its resources and manpower for the National Defense?

Only after these broader, somewhat intangible, questions have been answered favorably, should the committee give its consideration to the industrial advances and achievements that have resulted from group effort within the different companies. Since this award is on a biennial basis, it seems only logical to limit the present recognition to industrial developments that have come into fruition since December 1939. The governing rules and regulations have purposely been drawn with sufficient flexibility, however, that the committee can define "achievement" to mean any industrial advance or group of developments that, during the period under consideration, have reached the stage of successful commercial operation even though the original research may have been completed long before. There is no rule against a second award to a company or any of its subsidiaries or departments that have already received this recognition, provided that, in the opinion of the committee, there have been sufficient additional contributions to the industry and profession.

As evidence of their interest and willingness to contribute to this professional activity, the heads of chemical engineering in all of the accredited institutions have unanimously accepted our invitation to serve on the Committee of Award. As of May 1, 1941, there were 39 universities and colleges on the official list of those accredited by the American Institute of Chemical Engineers and the Engineers' Council for Professional Development. It has also been our privilege to designate as its chairman, Professor Alfred Holmes White, head of the Department of Chemical and Metallurgical Engineering, at the University of Michigan. Colonel White was a member of the original committee of award in 1933 and has actively served on each succeeding committee. A past-president of the American Institute of Chemical Engineers and member of its Committee on Chemical Engineering Education, his active interest in the profession now spans more than forty years of teaching experience.

Chairman White, all of the members of his committee and its secretary will welcome comments, criticism and suggestions from the readers of *Chem. & Met.* It is hoped that we may have your assistance in making this fifth Award for Chemical Engineering Achievement another important milestone in the advance of our profession.

S. D. KIRKPATRICK

Rules and Conditions Governing Award for Chemical Engineering Achievement

1. The purpose of this award is to encourage a broader participation by the chemical engineer in the affairs of the process industries by giving public recognition to that company which through the coordinated group effort of its chemical engineers has contributed the most meritorious advance to the industry and profession.

2. The award consists of an appropriate bronze plaque suitably engraved to indicate the nature of the achievement and the name of the company to which it is presented. The Fifth Award for Chemical Engineering Achievement is to be made at the time of the next biennial Exposition of Chemical Industries, which will be held in New York City during the week of December 8, 1941. This award applies only to industrial developments that have come to commercial fruition since December, 1939.

3. The award is to be made only to a company in the process industries since it is a recognition of the achievement of a corporate organization rather than that of any individual within a company. However, any company or any of its subsidiaries or departments would be eligible for the award on the basis of any number of achievements brought to the attention of the Committee.

4. The Committee of Award shall consist of the heads of chemical engineering in all of the educational institutions of the United States whose courses as of May 1, 1941 had been accredited by the American Institute of Chemical Engineers and the Engineers' Council for Professional Development.

5. It is to be the function of the Committee to review the achievements of the various companies, to receive suggestions from all sources and to determine which company has, in its judgment, contributed the most to chemical engineering during the interval under consideration.

6. Any company in the chemical process industries desiring to be considered for this award is urged to submit, in confidence, the following information:

(a) What is the nature of the achievement?
(b) During what period was it effected?
(c) To what extent have chemical engineers participated in the development?
(d) Are there any supplementary records, data, articles or references which should be included as pertinent to a fair consideration of the company's attitude towards its chemical engineers?

7. It is expressly understood, however, that this award is not limited to those companies which file formal applications with the Committee. Suggestions are desired from any and all sources that will assist in directing the attention of the Committee to the companies that should have consideration. Communications may be addressed to the Secretary, Committee of Award, *Chemical & Metallurgical Engineering*, 330 West 42nd St., New York, N. Y.

From Farmlands to TNT and Munitions Works

SIDNEY D. KIRKPATRICK Editor, *Chemical & Metallurgical Engineering*

How almost sixty square miles of fertile Illinois farmland is being rapidly transformed into a great munitions works for the production of high explosives and their loading into airplane bombs and artillery shells. Construction of the Kankakee Ordnance Works and the adjoining Elwood Ordnance Plant promises by August a goodly supply of materiel sorely needed for the defense program.

To a native son there is something almost sacred about the good, black earth of Illinois. Many years ago I wrote in my copybook, "Powerful, wonderful, splendid is our State —Illinois. Her prairies are a great, green garden and even under her earth lies treasure." Nowhere else in the world, or at least so it seemed to me then, could one find such fertile soil that year after year produced its abundance of corn and oats and soya beans.

But times have changed. We have an apparent surplus of farm products but an acute shortage of certain high explosives vitally needed in our national defense program. Military strategy, and certain economic and technical reasons as well, indicated that Will County, Ill., was an almost ideal location for Uncle Sam's largest combined TNT and shell loading plants. Some 280 farms of 38,000 acres were needed for the plant sites and these Illinois farmers and their families were none too happy about giving up their homesteads. Then one day last summer Colonel R. D. Valliant of the Quartermaster Corps in Washington made a hurried trip to the little town of Wilmington, Ill., to address a mass meeting of these farmers. He told them that the War Department definitely needed their land for its defense program and that no other location was under consideration for this plant. He assured them that they would get fair treatment at the hands of their government, whereupon they quickly dropped their protests.

Soon a vast wedge-shaped area between the Des Plaines and the Kankakee Rivers—which in all is larger than the land area of the District of Columbia—was being cleared of buildings and roads. The Kankakee Ordnance Works of approximately 35 square miles lies 14 miles south of Joliet and directly west of the small village of Elwood (population 300). Adjoining it on the south and practically surrounding the town of Wilmington (population 3,000) is the shell-loading works of the Elwood Ordnance Plant with an area of 22 square miles.

Early in September it was announced that the Kankakee Ordnance Works would be one of the Army's largest TNT and DNT high explosive manufacturing plants and that the general construction contract in the amount of $48,760,000 had been awarded to Stone & Webster Engineering Corp. On completion, the works will be operated by E. I. duPont de Nemours & Co., Inc., on a fixed fee basis. The Elwood Ordnance Plant is being built by the engineering firm of Sanderson & Porter at a construction cost of approximately $22,000,000 and it will be operated by the same organization.

A representative of Stone & Webster arrived in Joliet early in October and was followed a few days later by Lt. Col. T. C. Gerber, who was later to be commanding officer of both works. He is well qualified for this position, having graduated in engineering from the Rolla School of Mines & Metallurgy in 1917 and having served in ordnance since 1920 with at least four years of that period at Picatinny Arsenal in New Jersey. Actual construction started in mid-November after the surveying and soil testing had been completed. Despite the exigencies of the Illinois climate and the resulting mud, the construction work has proceeded according to schedule.

When I had the privilege of visiting the Kankakee Works on April 12, in company with Lt. Col. Gerber and Lt. Col. A. Robert Ginsburgh, of the Office of the Assistant Secretary of War, the site had been completely cleared and surrounded by 40 miles of non-climbable fence. Some 80 miles of serviceable roads had been laid out and construction was well advanced on at least 300 of the 450 buildings. Similar progress was being made at the Elwood Plant which is to have approximately 500 buildings, including the powder and ammunition magazines. Here there are to be 80 miles of paved road and 85 miles of railroad within the plant area. Transportation requirements of both plants are served by the main lines of the Santa Fe and Alton Railroads, by several main highways (one of which passes directly between the two plants) and by the Illinois Deepwater Way connecting Lake Michigan with the Mississippi River.

The gently sloping contour of the Kankakee site is particularly favorable to TNT operations. As one stands at the eastern boundary of the property, there is seen a very gradual but considerable decline to the West that will permit gravity flow of the liquid raw materials from the storage tanks through the nitrating steps to the grainer and packaging buildings. Toluol, which is to come from the government-owned plant at Baytown, Tex., (capacity 2,000 bbl. per day) and from coal-products plants in the Chicago area, is to be stored in 250,000-gal. tanks which will have a total storage capacity of 3,000,000 gal. Sulphuric acid will be shipped from chemical plants in the Chicago area to which the spent acid will be returned. Anhydrous ammonia for nitric acid

manufacture will come in tank cars from government plants at Morgantown, Va. and West Henderson, Ky., when these works are completed.

The production facilities of the Kankakee plant are divided between North and South areas, each of which will have six TNT lines with a parellel DNT line running between each pair. Each of the two areas will be served by its own acid plant, using ammonia oxidation units of the duPont pressure type, pictured last month in our description of the Charlestown smokeless powder plant. Electric power is to be purchased from the Public Service Co. of Northern Illinois, whose 132,000-volt line connects at one end with the great generating plant at Powerton near Chicago, and at the other end with another large steam plant at Peoria. Standby generating capacity for 2,000 kva. is installed in a power plant being built at the munitions works by Combustion Engineering Corp. Its primary purpose, of course, is to generate steam and compressed air for process use. Its capacity is 125,000 lb. of steam per hour at 375 lb. gage. The water supply comes from the Kankakee River and from Jackson Slough above its junction with the Des Plaines. The main water lines are of 42-in. steel pipe.

The Elwood Ordnance Plant is to be a shell loading and assembly plant. Empty shells and cartridge cases will be brought to the loading plant from scattered factories in the Middlewest. Bursting charges of high explosives will be received mostly from the adjoining plants of Kankakee Ordnance Works. Propelling charges of smokeless powder will be received in bags from the Hoosier Ordnance Works in Charlestown, Ind. and various other plants.

There will be three manufacturing or loading lines at Elwood. One line will manufacture airplane bombs, another will make fixed round ammunition, and the third will load artillery shells of various sizes. Airplane bombs shipped from Elwood will be completely assembled except for the fuses to be fixed at the last minute before they go into service. One of the unusual features of the assembly line will be a mechanical conveyor described as "several miles long" which will carry the shells through the long loading lines. This conveyor, costing approximately $500,000, is being constructed by the Alvey-Ferguson Co. of Cincinnati, in cooperation with the general contractor, Sanderson & Porter of New York.

Process equipment is uncrated and installed almost simultaneous with the construction of the various buildings

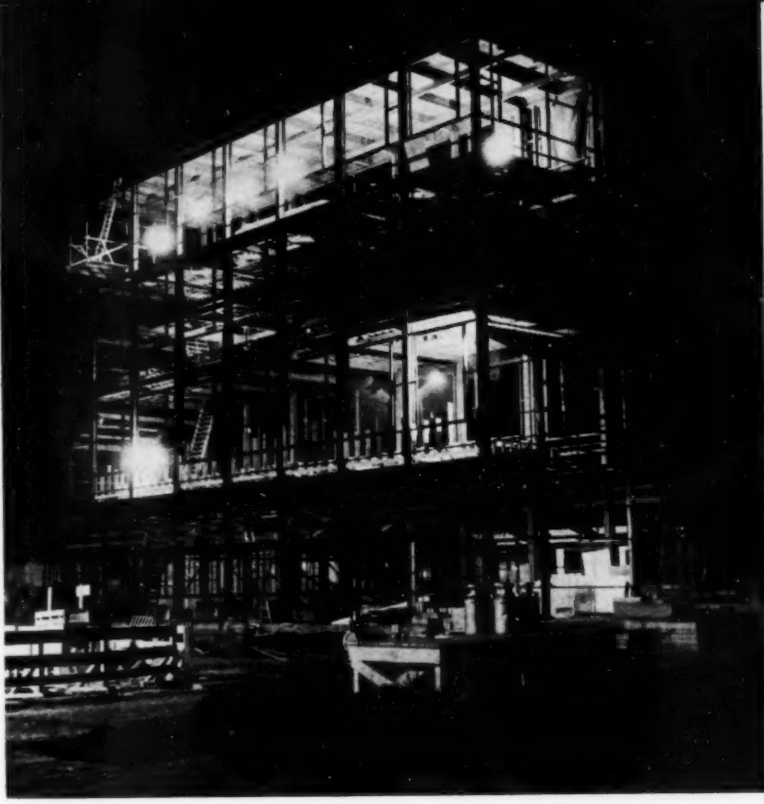
It is interesting to recall that in the 19 months we were in the first World War, the United States produced 375,656,000 lb. of high explosives for loading into shell. America was below France and England in total output during this period, but by November 18, 1918, we had reached a monthly output of 47,888,000 lb. as compared with 22,802,000 lb. for France and 30,957,000 lb. for England. (See *American Munitions*, 1917–18. Report of Benedict Crowell, Assistant Secretary of War).

Prior to August, 1914, we had a commercial production of only 600,000 lb. of TNT per month. By 1917 this had been raised to 1,000,000 lb. and by November, 1918, to 16,000,000 lb. In the meantime, the price had been brought down from $1 per lb. to 26½ cents at the time of the Armistice. Today, according to an address by Major General Charles M. Wesson before the Chicago Post of the Army Ordnance Association on March 17, 1941:

> The peacetime production of TNT in the United States is about 110,000 lb. per day. Small quantities of DNT and tetryl are also produced commercially. Facilities for the manufacture of 600,000 lb. of TNT and 100,000 lb. of DNT and 30,000 lb. of tetryl a day are now under construction at Wilmington, Ill. and Weldon Springs, Mo. Initial production of TNT is expected to start in August, 1941, and the balance of the capacity above mentioned should be attained by November 1, 1941. An additional 175,000 lb. of TNT and 30,000 lb. of DNT are to be provided at a plant near Sandusky, Ohio.

The importance of TNT as a military high explosive is based upon its relative safety in manufacturing, loading, transporting and storage, on the fact that it is not hygroscopic, on the lack of any tendency to form unstable compounds with metals and, upon its powerful, brisant explosive properties. Grade I TNT is used as the bursting charge for high explosive shell, either alone or mixed with an equal weight of ammonium nitrate to form 50/50 amatol. Grade II is used only in 80/20 amatol, where it is mixed in the molten state with four times its weight of ammonium nitrate. A charge of about 1½ lb. of TNT in a 75 mm. high explosive shell weighing about 10 lb. will, on exploding, break up the shell into approximately 400 fragments retained on a 4-mesh screen according to the War Department's Technical Manual 9–2900 on "Military Explosives."

Manufacture of TNT, according to this official reference source, involves the following processes: (a) Nitration of toluol to mononitrotoluol, mononitrotoluol to dinitrotoluol and dinitrotoluol to trinitrotoluol. (b) Washing finished product until free of acid. (c) Purification by remelting and chemical treatment or re-



Steel, wood and concrete construction are used in the 950 buildings needed for the Kankakee and Elwood plants

crystallization. (d) Granulation, screening or drying.

In the first stage of the three-stage nitration process, approximately 1,300 lb. of toluol is run into a nitrator containing about 1,200 lb. of mono-spent acid. The purpose of this spent acid is to provide a weak charge as a botton layer so as to prevent stripping of the nitrating acid which results in charred mononitrotoluol. Mixed acid, of approximate composition 76 percent sulphuric acid and 23 percent nitric acid, is added slowly to the mixture of toluol and spent acid through a spider distributor. The temperature is maintained at 50 deg. C. for the first 2,000 lb. and between 50 and 55 deg. C. for the next 3,000 lb. and at 55 deg. C. for the balance of the charge. After all the acid has been added, the charge is cooked for 10 minutes, cooled to 45 deg. C., allowed to settle for 15 minutes and the acid run off. The acid used in this nitration, where a plant is in continuous operation, is made up by fortifying the spent acid from the dinitration.

In the second stage of the process, the mononitrotoluol is blown to the di-tri-nitrating house and placed in the di-tri-nitrator. After cooling to 45 deg., mixed acid, usually made by fortifying the spent acid from a previous tri-nitration to bring up the nitric acid ratio to the same as that used in mono-nitration, is added to the mononitratoluol. The temperature is allowed to increase by 3-degree steps until it reaches 80 to 83 deg. C. where it is held until the nitration is completed. After all the acid is added the charge is cooked for 30 minutes and cooled to 60 deg. C. and then settled for 30 minutes.

It is in the third stage, when dinitrotoluol is being nitrated to TNT that most difficulty is encountered and extremely strong acids are required to complete the nitration. Approximately 3,500 lb. of fuming sulphuric acid is added to the di-oil, again controlling the temperature rise to 80 deg. C. Then mixed acid of approximate composition—57 percent nitric and 41 percent sulphuric acid—is added and the temperature allowed to rise gradually until it reaches 104 deg. C. Normally, after about three hours, the nitration is complete, although it is continued until the oil shows a freezing point of 72 deg. C. or higher. The charge is then cooled to 100 deg. C. and allowed to settle for 30 minutes, after which the spent acid is sent to be fortified and the trinitrotoluol to the neutralizing house.

Here begin the several steps in the purification process. The crude trinitrotoluol is first washed with warm water in conical-bottomed neutralizing tubs which are provided with steam coils for heating and air coils for agitation. Washing is continued until all free acid is removed. The neutral TNT, still in molten form, can be transported through heated pipelines to suitable storage tanks, or it can be pelleted by running into cold water and thus transported to the grainer house.

The graining kettles are of one-piece cast iron construction, jacketed at the bottom for use of either steam or cold water and provided with scraper-type plows. As the plow is started, the charge cools down and the crystals begin to form on the sides of the kettle. This increases until the whole mass becomes plastic. The graining is continued until all of the moisture is driven off and the TNT produced in fine crystalline condition. The product so made is usually better than Grade II TNT, that is, it has a melting point above 76 deg. C. If it is desired to obtain Grade I TNT recrystallization from either hot sulphuric acid or other suitable solvents, or treatment with other chemicals may be made. Pure TNT is a crystalline powder of very pale color. Commercial grades of the explosive vary somewhat in color but usually resemble light brown sugar in appearance.

The granulated TNT is packed in 50-lb. wooden boxes and loaded into freight cars that transport it to the magazines where it is stored. These are grouped together in the magazine area at Kankakee, spaced irregularly at 500 to 1,000-ft. intervals. The magazines are of the "igloo" type, constructed partly below the ground with concrete foundations, hollow tile or brick walls and corrugated metal roofs which are subsequently banked over with soil and planted with grass. Similar magazines are provided for temporary storage at the shell loading plant at Elwood.

If the excellent progress which the writer observed at these two plants in mid-April continues, as we have every reason to expect, they should begin production in August. Thus in only about nine months, 60 square miles of rich Illinois farmland will have been transformed into a thriving industry giving employment to at least 8,000 people including hundreds of inspectors and technically trained men. Some of these will come from other duPont plants. Some are already being trained in that company's pilot TNT plant at Barksdale, Wis., but most of the non-technical employees will come from nearby cities and villages. Let us hope that this vital productive capacity, once we get it and it has served its immediate purpose, is kept in standby condition so that this country shall never again be faced by a shortage of the high explosives so sorely needed for our national defense.

How Much Can Plastics Production

H. M. BATTERS *Market Editor, Chemical & Metallurgical Engineering*

JAMES A. LEE *Managing Editor, Chemical & Metallurgical Engineering*

Chem. & Met. INTERPRETATION

Much has been heard about the need for substituting plastics for such strategically important metals as aluminum and magnesium. But are the proponents of the plan fully aware of the raw materials situation in the plastics industry? A careful consideration of the background reveals the fact that several of the materials are every bit as vital to the defense program as the metals for which it has been suggested the plastic products be substituted.—*Editors.*

THE PLASTICS INDUSTRY has been making striking advances during the past decade and appears to be steadily gaining momentum. Now comes the request from the Office of Production Management that plastics be substituted whenever possible for such strategically important metals as aluminum and magnesium. At first thought this announcement would appear to give the industry a great opportunity, a tremendous boost. But an enormous expansion in the industry requires much larger volumes of chemical raw materials; are they available? A survey of production facilities for the chemicals required indicates that sufficiently large supplies of some will be available to take care of the greater needs, but in the case of other chemicals future supplies appear to be in a most uncertain position due to more important roles in the defense program.

The principal raw materials consumed in the production of phenolic resins are phenols and formaldehyde, and of lesser importance are cresols, cresylic acid, xylenol, furfural, fillers, dyes and pigments, catalysts, and so forth. During the first World War phenol was in active demand for the manufacture of picric acid and domestic production reached its peak in 1918 with a total of 106,794,277 lb., most of which was the synthetic product. Prior to 1914, domestic production ran about 1,000,000 lb. a year and came only from coal-tar.

As war-time demands increased, plants for synthetic production came into existence and in 1918 there were 17 plants operating. When the war ended, large stocks were on hand, estimated at close to 40,000,000 lb., or the equivalent of at least three years supply at the then normal annual requirements. The price dropped from 35 to 10c. per lb. and domestic production dropped to one plant (Barrett) making a small amount of phenol from coal-tar.

Phenol

In 1923, the rapidly growing automotive and radio industries widened the market for plastics and Dow Chemical Co. and Monsanto Chemical Co. again began the manufacture of the synthetic product. With the exception of some recessions in the lowest depression years, production has since been steadily upward. This is true both of natural and synthetic phenol. Production of natural phenol was stimulated by a growing demand for naphthalene which made it economically feasible to increase outputs of tar acids and phenol. It has been estimated that the 1937 production of more than 65,000,000 lb. was one-third natural and two-thirds synthetic but at present the percentage of synthetic production has increased as the Barrett Co. and Durez Plastics & Chemicals, Inc., have put new synthetic plants into operation within the year bringing the number of plants up to 10.

Official figures for 1940 production are not yet available but it is probable that it approximated 75,000,000 lb. Current rate of output is well ahead of the 1940 rate but production is well sold ahead and prospective buyers have been bidding far above the quoted price levels without being able to fill all their wants. In addition to domestic needs, there has been an active call for export and last year a total of 4,304,357 lb. was shipped out of the country.

With the scarcity of some of the metals and the recommendation that plastics be substituted where possible, earlier estimates for 1941 requirements of phenol have been revised upwards. While military requirements will fall far below those of 1918, they may account for about 15,000,000 lb., and estimating other requirements at 50,000,000 lb. for synthetic resins, 15,000,000 lb. for chemicals, 10,000,000 lb. for oil refining, and 5,000,000 lb. for exports, a grand total of 95,000,000 lb. is indicated. Judging from the status of the present market, demand is running ahead of supply and productive activities must be expanded if all needs are to be met. But this may not be a difficult task.

Cresols and Cresylic Acid

The Tariff Commission reported production of ortho, meta, and para cresols at 13,177,578 lb. in 1939, 11,403,420 lb. in 1938, and 13,745,271 lb. in 1937. Import trade in these products has been on an ascending scale in the last few years with totals reported at 48,660 lb. for 1938, 70,959 lb. for 1939, and 89,123 lb. for 1940. Production data for refined cresylic acid have not been given since 1934 when it amounted to 10,949,860 lb. Imports of crude cresylic acid are given in gallons and were 1,227,876 in 1938, 1,156,629 in 1939, and 1,063,489 in 1940. Formerly the term cresylic acid had reference to a mixture of 40 percent meta cresol, 35 percent ortho cresol, and 25 percent para cresol; that is, a mixture of the cresols in the same proportions as they occur in coal-tar. Later, the term has been used for varying mixtures of cresols to suit the requirements of individual users. From

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Based on paper presented before the Society of the Plastics Industry, at Hot Springs, Va., May 6, 1941.

Be Expanded?

Courtesy Bakelite Corp.

the first of this year, byproduct plants have been turning out coke primarily for the steel industry. By operating at higher temperatures with shorter coking time, the cresol and xylol content of the tar is greatly reduced. This has been reflected in the output of both materials and a serious situation has developed from which no improvement is likely to occur.

Formaldehyde

Figures for domestic production of formaldehyde were reported by the U.S. Tariff Commission for 1933 and prior years but no data were given for the 1934-1938 period. With the exception of 1927, the output increased steadily each year from 1922 through 1929, production for the latter year amounting to 51,786,000 lb. In 1933 production was reported at 52,236,000 lb. From that year up to 1939 no comparable data are available but it is known that production was on an increasing scale and the total for 1939 was given as 134,479,000 lb. which undoubtedly was a record for the industry. In addition to its use in resin manufacture, formaldehyde finds important outlets in indigo manufacture, in making sodium sulphoxalate formaldehyde, as a disinfectant, deodorant, and preservative, as fungicide, in embalming fluids, in tanning, and in making wall paper and coated paper. In recent years there has been a rising call for formaldehyde in the export trade with more than 5,700,000 lb. shipped abroad in 1940 and with monthly shipments so far this year being in excess of the 1940 rate.

The rapid rise in production of formaldehyde has been due to the increase in output of resins. As formaldehyde is made from methanol, it follows that its production is limited not only by existing plant capacities but also by the amount of available methanol. At present there are four domestic producers of formaldehyde, two of which produce methanol.

Domestic production of methanol has been more than doubled in the last six years with the increase being entirely in the synthetic product. While production of formaldehyde also has more than doubled in the same period, this alone would not account for the sharp rise in methanol output. The largest distribution of methanol is in the anti-freeze trade. Last year formaldehyde accounted for about 20 percent of the methanol supply. Synthetic methanol, which accounts for about 90 percent of total domestic supply, is made by four companies.

Production in the first quarter of this year was 10,263,479 gal. of synthetic and 1,339,425 gal. of crude.

With the abnormal demand for nitric acid which lies ahead, unusually large amounts of ammonia must be made available and already some of the methanol capacity has been turned over to ammonia production. Production data for February this year showed a drop of more than 600,000 gal. for methanol as compared with the corresponding month of last year. Difficulties in securing some of the equipment necessary for new ammonia plants is causing delays in placing these plants in operation. Should a greater part of methanol capacity be switched over to ammonia, the supply available for formaldehyde and other uses will not be sufficient. Scarcity of both formaldehyde and methanol already has been reported in domestic markets. Application of control or allotment of shipments would work a hardship on producers if the anti-freeze market should be curtailed since the position methanol has attained resulted from long and costly sales programs which have given prominence to special brands.

Methanol Production

Year	Synthetic 1,000 gal.	Crude 1,000 gal.
1940	44,968	5,294
1939	34,256	4,660
1938	26,031	4,170
1937	31,814	5,754
1936	25,563	5,575
1935	18,047	5,049
1934	12,534	4,122

Urea resins are often associated with phenolics as both groups have a raw material, formaldehyde, in common. Production of urea resins averaged less than 4,000,000 lb. in 1933-35, but since then have gained steadily in importance and in 1939, 16,569,343 lb. were produced with eight companies in the field. And at the present time two large plants are nearing completion, which will greatly increase the manufacturing capacity of the industry.

Urea

Production of urea in this country is confined to one company and figures for the output are not available. Prior to 1935, requirements for crystal urea were met by importations but from that time on, domestic material has been prominent and arrivals from abroad have been consistently declining. Imports reached their peak in 1930 when they exceeded 20,000,000 lb. By 1937 they had dropped to a little more than 5,000,000 lb., and as Germany was the principal supplier, it has been

difficult to secure foreign material since the outbreak of hostilities and imports in 1939 fell to 1,464,000 lb. with no arrivals reported in 1940. Hence the question of urea supplies is now a domestic problem. Ammonia is one of the essential raw materials required for urea production and the uncertainty surrounding future ammonia supplies is equally applicable to urea.

Acetic Acid and Anhydride

Cellulose acetate producers appear to be in a comparatively secure position regarding the chemical raw materials, acetic acid and acetic anhydride. Plant capacities for acetic acid were considerably expanded in 1939 and 1940 and apparently can be further increased should the necessity arise. Considering the variations in process and raw materials used there is no indication that acid supplies will be limited despite the rapid gain in consuming requirements which has been noted in recent years. Prior to 1926 all domestic acetic acid production was from acetate of lime. At present in addition to the output of the hardwood distillation industry, synthetic acid is being made from acetylene, methanol, and ethyl alcohol. Possible shortages in some of these raw materials undoubtedly could be made up wholly or in large part by greater production from the materials available.

The situation with regard to acetic anhydride so closely parallels that reported for the acid that the same conclusions will hold good for that product.

The Tariff Commission has published figures annually for production of acetic anhydride. Production on basis of 100 percent was:

Acetic anhydride production

	lb.
1939	181,156,152
1938	114,835,504
1937	177,488,353
1936	136,889,876
1935	116,469,109
1934	67,335,274
1933	57,885,123

The Tariff Commission also gives production of acetic acid, basis 100 percent, from 1937 on. The figures are:

Acetic acid production

	lb.
1939	119,652,650
1938	97,478,563
1937	125,509,931

The Bureau of the Census did not include acetic acid in its returns for 1939 but reported production in 1937 and 1935 at 131,644,596 lb. and 101,500,662 lb. respectively. The total reported for 1933 was 65,150,478 lb.

Cotton Linters

There are three cotton linter purification concerns whose plants have sufficient capacity to handle all the linters we may ever require since their operations are limited only by the amount of linters available from the cotton crop. But the linter supply is not large enough to meet the requirements of plastics, rayon, and smokeless powder. Since high-grade powder can be made from alpha cellulose, the smokeless powder plants are being urged to use this material. However, the Army is slow to adopt a new material, therefore, the expectation is that for some time, it will demand linters which in turn, will create a shortage when present stocks have been consumed. There also is the possibility of the government using its influence on the industries concerned to use the cotton now in storage. But this will be an expensive source of cellulose and it too will require a certain amount of purification.

Nitric Acid

Nitrocellulose depends upon linters and nitric acid. Because of its paramount importance in the munitions field, nitric acid must be considered as one of the key chemicals whose use in ordinary channels may be determined by the extent to which its finished products are classified as essential. Production of nitric acid, basis 100 percent, is estimated at 200,000 tons in 1940 and annual requirements with the defense program in operation are estimated at 1,000,000 tons. Under present procedure, practically all the nitric acid produced in this country comes from the oxidation of ammonia.

Last year, ammonia production is estimated at about 395,000 tons which figure must be raised above 700,000 tons to meet the prospective demand. Consuming call for acid has been increasing more rapidly than ammonia plant capacities can be expanded. Fortunately Canada has made considerable progress with its ammonia plants and will have a surplus which can be used to avert an actual shortage in the early operations of our new powder plants. New domestic ammonia production then will take up the slack but there is as yet no assurance of full coordination of ammonia supply and acid requirement.

In addition to new plants for ammonia, equipment now used in making methanol and synthetic nitrate of soda can be turned over to ammonia. There also is the probability that an additional acid supply may be found by utilizing the former method of making it from Chilean nitrate of soda. In the meantime the buying season in the fertilizer industry is passing and this will release some ammonia for other purposes. Later on the fertilizer and other industries may be called upon to seek other sources for their nitrogen requirements. Despite all these expedients, it is generally regarded that ammonia will be in a tight position for some time to come and as military quotas undoubtedly will be given preference, whatever amounts remain for general distribution may be allocated on a basis of industry importance.

Phthalic Anhydride

As its name indicates phthalic anhydride is the basic material upon which phthalic anhydride resin production depends. Phthalic anhydride itself is made from naphthalene, hence these with glycerin are the important raw materials for this type of resin. In 1933, domestic production of the resin was reported at 9,931,000 lb. which included small experimental lots of resin made from maleic anhydride. The 1939 total shows a more than seven-fold increase in the eight-year period. In the same period, phthalic anhydride production increased from 14,076,000 lb. to 44,274,000 lb., or in the eight years there was a gain of more than 60,000,000 lb. in the resin output and only a little more than 30,000,000 increase in the raw material output.

As phthalic anhydride has been used in recent years in a larger volume in the manufacture of plasticizers, it is evident that its proportionate use in the resins has been declining. A few years ago it was estimated that approximately 60 percent of this type resin was made up of phthalic anhydride which would make resin requirements for phthalic anhydride in 1939 about 42,000,000 lb. but this amount would not be available when allowance is made for non-resin requirements for the raw material. Production of phthalic anhydride has been as follows:

1940	44,274,000 lb.
1938	27,650,000 lb.
1937	45,211,000 lb.
1936	31,244,000 lb.
1935	23,422,000 lb.
1934	20,680,000 lb.
1933	14,076,000 lb.

At the present time there is a scarcity of phthalic anhydride and there are rumors that large volumes are going into dibutyl phthalate for use in explosives. If this is the case the supply available to the synthetic

resin industry will become smaller. However one producer is planning to double present plant capacity.

Naphthalene Production and Imports

Owing to the relatively small demand for pitch and creosote oil, domestic production of naphthalene never has reached its full potential based on the output of coal-tar. As a result, imports have been necessary to fill out consuming needs. Crude naphthalene is used in making phthalic anhydride and the bulk of imports also are of the crude material. More than one-half of domestic supplies—home production plus imports—is refined and is used in making intermediates, dyes, disinfectants and in numerous other ways including the manufacture of trinitro naphthalene. Domestic production of naphthalene has been increasing and from present indications a new record for output will be established in the present year. Imports in 1940 amounted to only 6,290,380 lb.

Glycerin

As glycerin is a byproduct of soap and fatty acid manufacture, it follows that the home output is dependent on activities within those industries rather than on consuming demand. Foreign trade in recent years has shown a balance in favor of exports with imports consisting largely of crude and exports running mostly to refined. Domestic production has been gaining steadily and the same is true for consumption. Total supply of crude in 1940—home production plus imports—was slightly in excess of 206,000,000 lb. As stocks increased only a little more than 5,000,000 lb. in the year, apparent consumption was approximately 201,000,000 lb., this total including the amount of crude which was refined and exported. While glycerin has lost ground in some of the consuming trades, notably anti-freeze and closure, it has gained appreciably in other directions with alkyd resins offering the most important outlet.

Glycerin Production

Year	Crude 1,000 lb.	Imports 1,000 lb.	Total supply 1,000 lb.
1940..	197,096	9,096	206,192
1939..	184,476	10,987	195,463
1938..	162,120	13,097	175,217
1937..	169,039	13.598	182,637
1936..	154,096	11,149	165,245
1935..	141,185	8,221	149,406
1934..	153,115	14,901	168,016
1933..	119,812	6,205	126,017
1932..	133,919	5,184	139,103

Acetone

Production of acetone in 1937 was reported at 124,012,187 lb. of which 68,772,268 lb. was reported as sold. For 1938 and 1939 only the amounts sold were reported, these being 67,041,184 lb. and 68,772,268 lb. respectively. It is estimated that production in 1940 was 130,000,000 lb., but demand both at home and for export was exceptionally heavy and surplus stocks were not in evidence. Latest reports place acetone in a strong statistical position with production passing directly into consumption. Export shipments are holding up in volume and as a large part of production has been sold ahead, any material increase in demand may be difficult of fulfillment.

Vinyl resins have been increasing in importance in recent years and this growth has been reflected in increasing demands for the raw materials, butylaldehyde, vinyl acetate and vinyl chloride. The acetate is made from acetylene and acetic acid and the chloride from acetylene and hydrochloric acid.

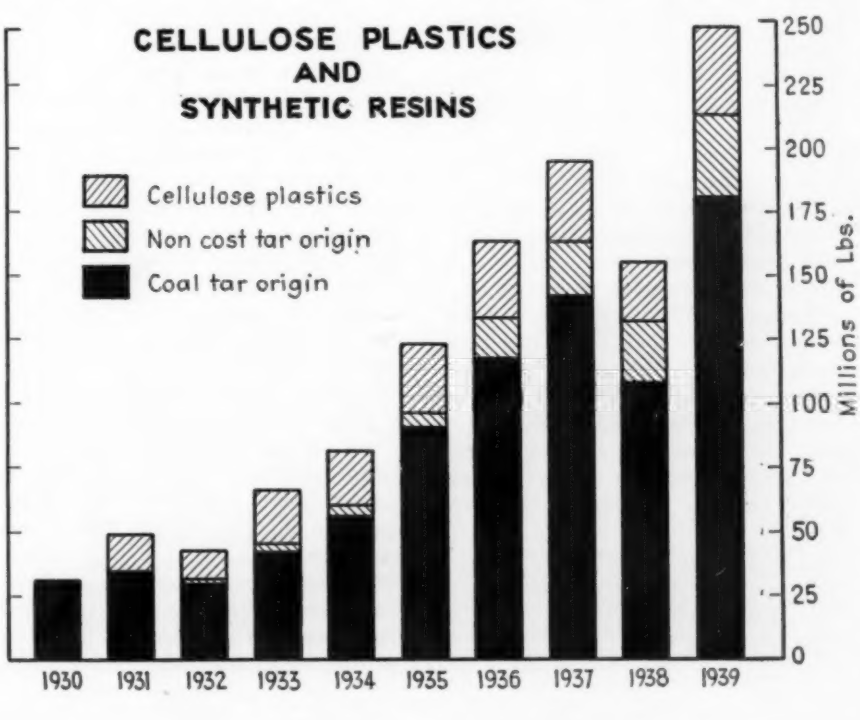
The supply of acetic acid has already been discussed. There should be no shortage of acetylene, which is produced from carbide, the electric furnace product of coke and lime. The supply of hydrochloric acid appears to be ample. But the government is taking the output of polyvinyl chloride so additional production facilities will have to be provided.

Polystyrene is made from ethylene and benzene. The former comes from petroleum or natural gas and the latter from byproduct coke ovens. There should be no shortage of these raw materials.

Acrylic and methacrylic resins are made by polymerizing derivatives of acrylic acid. Raw materials are methanol, acetone, sulphuric acid, and hydrogen cyanide or sodium cyanide. Of these raw materials the only ones that may cause concern are methanol and acetone. As stated earlier, a very real shortage is expected to develop in methanol due to the necessity for using the methanol plants to produce ammonia for defense purposes. However, the producers of this type of resin should be able to obtain sufficient methanol for their requirements as it will be used to produce airplane windshields, cockpit enclosures and other parts for machines needed by our army and navy.

Coumarine and indene resins are made by polymerization of coal-tar fractions, especially solvent naphtha fractions. The polymerizing agent is usually sulphuric acid although some metallic salts are sometimes used. At times such as these when the steel industry is operating very near capacity, the demand for coke is greatly increased, which in turn results in large amounts of coal-tar. As some of the largest producers of the resin are also producers of coal-tar, the question of supplies rests with whatever adjustments they make regarding the use of the coal-tar. Polymerizing agents are plentiful.

One of the newest of the plastics to come on the market is vinylidene chloride, a resin said to be made from ethylene and chlorine. The ethylene is obtained from cracked petroleum gases or natural gas. There should be no shortage of these materials.



Investing in the "Chemicals": The Stocks

ROLAND P. SOULE *Tri-Continental Corporation, New York City.*

Chem. & Met. INTERPRETATION

Last month Dr. Soule oriented the chemical industry both historically and financially in relation to the nation's economy as a whole. In the present article the author explains ten reasons why chemical earnings command a premium in the stock market — ten basic characteristics of the industry that are of vital interest to every chemist and chemical engineer. — *Editors.*

Many investors who are favorably impressed by the chemical industry as an industry cannot bring themselves to buy chemical stocks. "The chemical industry is prosperous and growing," they are willing to admit, "but its stocks sell too high and yield too little." Good reasons are to be found, however, for believing that such a criticism is unfounded.

Price-Earnings Ratios—The price of a stock concededly must bear some relationship to its earnings, and this relationship is commonly described as its "price-earnings ratio." If a stock is selling at 30 and earning \$2 a share, its price-earnings ratio is 30/2, or 15. Under the so-called "normal" conditions that prevailed between the end of the depression and the outbreak of the war, the average price-earnings ratio of good grade industrial stocks, as typified by the Dow-Jones list, was in the neighborhood of 14.* A stock having such a ratio might pay out approximately 80 percent of its earnings as dividends and hence would yield about 5¾ percent.

Compared with this average, however, many stocks always sell much lower while others are priced considerably higher in relation to their profits per share. At any one time the investor may have his choice between one stock offered as low as five times earnings and yielding possibly 15 percent, and another quoted at 25 times earnings and returning only 2 percent. Yet the former stock may prove to be the more expensive and the latter the real bargain.

Conditions of supply and demand in the market have placed the nine largest and most diversified chemical companies in the group of stocks having the highest price-earnings ratios. In Table I these companies comprise the first eight (excluding Texas Gulf Sulphur Co.) on the N. Y. Stock Exchange list, plus American Cyanamid on the Curb. Together they account for over 90 percent of the total market value of all publicly-owned chemicals. The price-earnings ratios of stocks of these nine companies in normal times averaged close to 20, or half again as high as the mean of the 30 "Dow-Jones industrials."

THE CHEMICAL STOCKS

Ideas naturally cannot be subjected to quantitative analysis, but at least they can be approached qualitatively. Thus, it is possible to enumerate ten factors that, consciously or unconsciously, are in the mind of the intelligent investor when he asks himself if a particular stock is a good purchase. These are the considerations which appear to entitle the leading chemicals to sell higher relative to earnings than do most of the 700 other industrial stocks listed on the N. Y. Stock Exchange.

Trend of Growth—A more rapid trend of earnings is the point most often advanced in favor of chemical stocks, but it would be next to impossible to defend their high price-earnings ratio on this score alone. Their actual rate of growth, as measured in percent per year, has not been spectacular and has been exceeded by many other stocks with considerably lower ratios. It is not the magnitude but rather the steady, relentless *nature* of their trend that is significant marketwise.

In the ten years ending in 1937, when general business as a whole made no gain in profits, many industrial companies reported sharp increases in earnings that might superficially be regarded as evidence of a strong growth trend. More careful analysis indicates that not all such increases were due to growth in its truest sense, and that not all growth holds the same promise of continuation. Thus, three types of trend may be recognized:

1. False Trend

a. Resulting from decline in interest rates (Commercial Credit and Commercial Investment Trust);
b. Resulting from devaluation of gold (Homestake, Dome);
c. Resulting from repeal of prohibition (National Distillers, Owens-Illinois Glass);
d. Resulting from legislation making safety glass mandatory for automobiles (Libbey-Owens-Ford; Pittsburgh Plate Glass);
e. Resulting from war or threat of war (United Aircraft, Curtis-Wright).

The outstanding characteristics of this trend is that it is non-recurring. Earnings are simply raised from one flat plateau to another and usually not because of any efforts on the part of the management.

2. Limited Trend

a. In industries, illustrated by the increasing per capita consumption of some commodity, usually of a consumers' goods type; in soft drinks (Coca Cola); in cigarettes (Liggett & Myers); in electric appliances (Chicago Flexible Shaft); in vitamins (Abbott Laboratories, National Oil Products);
b. In individual companies, illustrated by the capture of a larger share of total available business in an industry which itself may or may not have any growth; by more intensive sales (Chrysler in automobiles, Deere in farm equipment; American Chicle in gum); by more extensive sales, such as opening more stores in new territory (Montgomery Ward; Sears

* Changes in market sentiment during this period rarely caused individual price-earnings ratios to fluctuate more than plus or minus 15 percent. At present, however, all ratios are sharply lower because of the war-engendered uncertainty over the future outlook for corporate profits.

Roebuck; and Western Auto Supply in retail trade); by increasing production facilities (Humble and Amerada in crude oil).

The characteristic of this type of trend is that inevitably it comes to an end. Markets approach saturation or competition is intensified.

3. True Trend

a. In industries, illustrated by the development of new and different markets for existing products (International Nickel and Aluminum Co. in metals; all of the leading chemical companies);
b. In individual companies, illustrated by the addition of new products to existing lines (General Electric, Westinghouse, Armstrong Cork, International Business Machines; all of the leading chemical companies).

The distinguishing characteristic of this true trend is that it holds promise of ever-continuing growth. Stocks with such a trend do not require constant watching, and can be bought and held at almost any level of the business cycle. *So long as earnings and dividends continue to expand, the current yield on the original purchase price also increases proportionately.*

Diversification—A diversified business (in products, in markets, or in both) probably contributes more to a high price-earnings ratio than simply a strong trend in growth. The average investor is more interested in security against unexpected depreciation than in an uncertain possibility of appreciation. Thus, companies such as General Electric, Westinghouse, Johns-Manville, Allied Chemical, and Corn Products showed little or no expansion in earnings over the past ten years, but all sold at 20 or more times earnings.

Industrial Strength — The best chemical stocks have most of the qualities which comprise that intangible asset known as "industrial strength":

1. Fairly staple products, with comparatively little dependence upon style factors and changing public taste;

2. Relatively few companies making any given product, and intelligent trade relations between the managements of those companies;

3. Defenses against irresponsible competition, such as control of raw materials, high capital investment to obtain competitive costs, technical "know-how," and patents;

4. A small proportion of total sales in foreign countries.

Financial Strength—Leading chemical companies all have (1) freedom from burdensome senior capital, (2) adequate depreciation charges, and (3) very comfortable working-capital positions.

Depreciation rates, which are about half again as high as those of the average industrial concern, enable chemical manufacturers to replace outworn and outmodeled equipment and keep pace with the times. The adequacy of these rates is reflected in the strength of their balance sheets, with current and cash ratios well above the average of most manufacturing companies.

Resistance to Cyclical Declines—Chemical companies are by no means immune to the forces of depression, but only appear so in periods when growth trends are making themselves strongly felt. During short, sharp recessions, such as occurred in 1937-1938, their earnings fell just as sharply as those of non-chemical companies serving the same markets. It is noteworthy, however, that these markets have a substantial weighting of stable consumers' goods such as dyes, textiles, soap, paper, and food. The average industrial stock publicly traded today has a greater dependence on more volatile capital goods such as steels, automobiles, and equipment for the farm, home, and office.

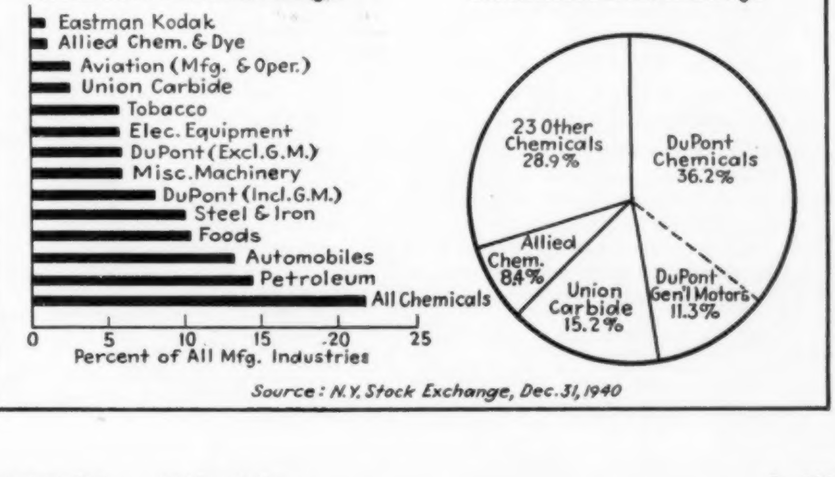
Relationship to Research—Expenditures for research in the United States are not uniformly spread over all industries but are relatively highly concentrated in three industries: chemical, electrical (including communications), and petroleum, in the order named.* The chemical industry, accounting for less than 7 percent of the total value of manufactures, contributes over 20 percent of the total spent for research in this country each year.

* "Industrial Research and Changing Technology." WPA National Research Project (January, 1940) directed by George Perazich.

All constructive and successful research rebounds to the benefit of the consumer. He is given an article that is improved in quality, lowered in price, or extended in life. Such research, however, is not always equally beneficial to the stockholder. Thus, if a company is doing business largely on a replacement basis in a relatively inelastic market, profits may suffer when the price of the product is reduced and its life is lengthened. Ample illustrations are to be found in tires, radios, refrigerators, electric bulbs, and more recently even in automobiles. The problem faced by General Electric, for example, is to develop new products through research at a rate fast enough to offset the shrinkage in earnings due to improvements in older lines.

Chemical research in general has been among the most consistently profitable of all types of commercial experimentation. In an orderly and unhurried fashion new markets have been developed, new products originated, and new processes developed to reduce costs. It is upon continued and expanded research of this nature, as a matter of fact, that the chemical companies must chiefly rely for their greatest hope of maintaining a steadily upward trend of sales and earnings.

Reduction in Prices — "Chemical prices never go up" is a slogan commonly heard in the industry. The trend has been generally downward, but declines have not been so drastic that aggregate profits have suffered. While there are exceptions to this generalization, particularly in the older, inorganic lines, price reductions for the most part have been voluntarily made to expand sales volume. U. S. Bureau of Labor price indices show that of all raw materials, semi-manufactured and finished products, only chemicals are



now quoted under their 1913 levels. They participated only moderately in the 1920 boom, and are now selling even below their 1932 lows. Obviously, chemical products are not faced by any threat of a general price deflation. Nor is there need to fear any broadly adverse effect from a period of inflation. Chemical price structures are flexible, and opposition to advances usually is relatively slight.

Labor Relations — Outside the rayon division, which is under the influence of the C.I.O. textile union, chemical companies have suffered comparatively little from labor difficulties. The nature of the industry itself is in large part responsible. Seasonal peaks of production, such as encountered in the manufacture of automobiles, are rare, and the annual load factor is high, with continuous seven-day operations quite characteristic. Also, production wages and salaries do not constitute a large proportion of the sales dollar. In 1939 they accounted for less than 17 percent[1] compared with over 40 percent in the steel industry.[2] The quality of the chemical worker is unusually high. His average weekly wages in 1939 were over $31 compared with less than $25 for all factory employees,[3] and a larger proportion of workers were on salary.

Chemical companies have been leaders in pension and insurance plans. They have pioneered in vacations with pay for factory workers. They have concentrated on safety measures, so that despite the hazardous nature of many manufacturing operations, accident frequency and severity rates in 1939 were respectively 37 and 11 percent below the average of all industry.[4]

From the standpoint of the labor agitator, chemical companies in general are difficult and unattractive to organize on a union basis. Their plants are numerous (the three largest companies have over 100 each), they are geographically scattered, and workers differ widely in type as as well as in occupation.

Public Relations—Relations of the chemical industry both with the public and with government have been unusually favorable:

1. Unlike steel, coal, and textile industries, it does not employ any large and homogeneous portion of the country's total workers; hence, politicians are not tempted to make political capital by backing higher wages;

2. Unlike dairy companies and meat packers, it does not purchase any important part of its raw materials from the farmer, who is politically favored and desirous of higher prices;

3. Unlike the utilities, food companies, gasoline refiners, and chain stores, it does not sell familiar products directly to the general public, with resultant vulnerability to pressure for reduced prices (the fertilizer division is an exception);

4. Unlike the construction industry, it is not lagging behind the rest of the economy, so that government intervention has not resulted;

5. There have been no Van Sweringens or Insulls to bring down public wrath; on the contrary, there seems to be a general feeling that the chemical companies have done a good job;

6. The complexities, technicalities, and general heterogeneity of the chemical industry tend to make it relatively immune to political attack.

Quality of Management—Although named last, the uniformly high quality of the management of the larger chemical companies is obviously an asset of prime importance. This quality is reflected in a number of respects already discussed:

1. In conservative fiscal policies;
2. In research policies, which are progressive and constructive;
3. In price policies, which are pointed downward in line with reduced costs and expanded unit volume;
4. In labor policies, which are forward-looking;
5. In inter-company relationships, which are based on intelligent, rather than cut-throat competition;
6. And, finally, in public relations, which are cordial.

A popular and growing industry attracts talent. The new generation of chemical executives is as capable and as enthusiastic as the old. It is even better trained technically.

Table I—Market Value of Chemical Stocks Listed on N. Y. Stock Exchange, Dec. 31, 1940

($000,000 omitted)

	Market Value[1]	Percent of Total
DuPont		
Chem. Operations..	1,536	36.2
Genl. Motors......	480	11.3
Total DuPont....	2,016	47.5
Union Carbide.......	645	15.2
Allied Chemical......	358	8.4
Eastman Kodak.....	354	8.3
Dow Chemical.......	144	3.4
Texas Gulf Sulphur..	141	3.3
Monsanto	118	2.8
Air Reduction.......	110	2.6
Hercules Powder.....	103	2.5
Columbian Carbon....	41	1.0
Freeport Sulphur.....	30	0.7
Commercial Solvents..	29	0.7
Mathieson Alkali.....	27	0.6
Atlas Powder........	25	0.6
United Carbon.......	19	0.5
Victor Chemical......	17	0.4
National Cylinder Gas	14	0.3
Westvaco Chlorine....	12	0.3
Amer. Agric. Chem...	10	0.2
U. S. Indl. Chemical.	9	0.2
Tennessee Corp.......	7	0.2
National Oil Products.	5	0.1
Newport Industries...	5	0.1
Davison Chemical....	4	0.1
Virginia-Car. Chem...	1	....
Int'l Agric. Corp.....	1	....
Total[2]	4,245	100.0%

[1] Exclusive of market value of bonds outstanding.
[2] For comparison: most important chemical stock on Curb Exchange is American Cyanamid ($99,000,000); most important rayon stock is Celanese ($67,000,000).

CONCLUSIONS

It would be wrong to create the impression that all is well with chemical stocks. They are at present the victims of their own virtues. Their higher-than-average rate of return on invested capital and their strong upward trend of earnings have made them particularly vulnerable to the excess-profits tax. It has been easy to assume that taxes will make growth impossible, and hence to conclude that without growth a high price-earnings ratio is unjustified. This feeling was reflected in the action of the leading chemicals, which despite their excellent earnings, performed more poorly in the last half of 1940 than the market as a whole.

Weight of evidence suggests, however, that the sale of chemical stocks solely because of higher taxes will prove in the long run to be a shortsighted policy. For one thing, while growth in profits has been greatly retarded, it has not been entirely killed and certainly not permanently stopped. Also, the current high rate of earnings is due far more to increased sales of peace-time products than to the manufacture of munitions. Much of the present business will survive in the post-war period, when the excess-profits tax may disappear as it did after the first World War. Granted that normal taxes still may remain very high, the chemical concerns will be better equipped to meet them than most companies.

Industrial corporations are like nations in that they cannot indefinitely stay in one place. They are continuously exposed to the erosive forces of change, and must either press forward or fall backward. The concept of entrenched stability of earning power is no more effective for a manufacturing company than the Maginot line was for France. The only sure defense is attack—which in business means new methods, new products, and new markets. In this attack, one group of companies stands out as preeminently qualified to face the future. That is what appeals most to the man who invests in the "chemicals."

[1] Federal Trade Commission report on chemical manufacturing companies.
[2] Annual reports of U. S. Steel Corp. and Bethlehem Steel Corp.
[3] U. S. Department of Labor.
[4] National Safety Council.

Submerged Combustion as Applied to Sodium Sulphate Production

E. W. DOUGLASS and C. O. ANDERSON *Ozark Chemical Co., Tulsa, Okla.*

Chem. & Met. INTERPRETATION

Glauber's salt was first produced on a large scale in 1767 by freezing a salt brine on cold winter nights. At its Monahans, Tex., plant the Ozark Chemical Co. resorts to this same chilling principle to recover the salt by artificial refrigeration of a natural brine occurring underground. In dehydrating the salt, submerged combustion is applied to produce a high quality anhydrous sodium sulphate which can meet requirements of practically any industry.—*Editors.*

PRESENT-DAY literature on chemical technology usually relates to new compounds and often gives the impression that the older ones are being neglected. Hence a new development, such as the application of submerged combustion (burning of a fuel, such as natural gas, within the body of a liquid) in the commercial production of sodium sulphate creates interest among chemical technologists.

Becoming aware of the temporary acute shortage of salt cake in 1929–1930, the Ozark Chemical Co. undertook investigations which resulted in the building of a sodium sulphate plant alongside a so-called "alkali" lake 13 miles south of Monahans, Tex. Although this plant began commercial operations in 1933, and has operated continuously since that time, much difficulty was experienced in devising a satisfactory method of dehydrating Glauber's salt to the anhydrous form.

Reasons for many of the difficulties encountered in dehydrating Glauber's salt are disclosed by the water-solubility curve of sodium sulphate. The solubility increases with the temperature as long as the stable solid phase is the decahydrate, but at 93 deg. F. the anhydrous salt becomes the stable one and continues as such to the boiling point. Beyond 93 deg. F. solubility of the anhydrous decreases, quickly at first and then slowly. This inverted solubility characteristic means that from a saturated solution undergoing evaporation, the anhydrous salt forms a heavy scale rapidly on the heating surfaces of the equipment. To cope with this tenacious sealing characteristic many procedures have been proposed and practiced.

In the field of evaporators, equipment with a number of steam chests employed in rotation, have been used; one chest is de-scaled while the others are in service. In this field also, forced or rapid-circulation evaporators in which high velocities through the tubes and small temperature changes are maintained, have been operated on sodium sulphate duty. To reduce this scaling in evaporators, a procedure sometimes followed is to operate at temperatures at which the saturation curve is relatively flat; the reason given is that the decrease in solubility for a given temperature increase is small and hence scaling should be less pronounced.

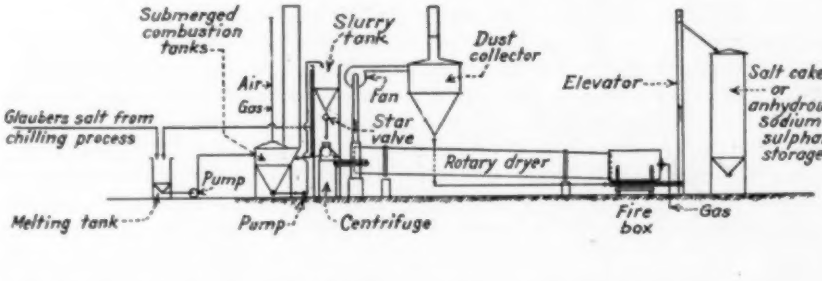
Rotating steam drums have been employed in the evaporation of sodium sulphate solutions. The drums, partly submerged in the liquid, are heated internally with the steam under pressure. As the drums rotate the coating of sodium sulphate picked up during submergence is scraped off by properly placed knives. Main objection to this procedure is the large amount of evaporating surface required per unit of production; the tenacious adherence of the sodium sulphate to the drum surface is a major obstacle to satisfactory functioning of equipment.

Equipment for drying Glauber's salt at temperatures below 93 deg. F., the transition or melting point, has been patented but obviously such equipment can have no substantial capacity. For example, a factor militating against the use of such equipment is that the temperature of atmospheric air throughout the summer in much of the United States exceeds this figure. No commercial production by this means is known.

An apparently satisfactory method where common salt is available at very low cost is to precipitate the sodium sulphate from solution through preferential dissolving of sodium chloride. The sodium sulphate is thrown down as the anhydrous salt from its hot solution through the addition of the sodium chloride. As the cost of common salt must be almost negligible few locations qualify for the use of this method.

Another procedure for converting Glauber's salt to the anhydrous form is to melt it in a stream of hot sodium sulphate slurry, to separate the anhydrous salt by filtration and to return the saturated filtrate to the top of a tall tower, down which it showers and meets ascending hot gases which accomplish evaporation.

Diagram of Ozark Chemical Co. plant for sodium sulphate production by submerged combustion, showing dehydrating operations



The slurry from the bottom of the tower retraces its cycle. This method has been practiced in South America.

Large direct-fired rotary dryers have been used for dehydrating Glauber's salt, particularly at locations where the salt has been stock-piled and partially air-dried.

All of the described methods with the possible exception of the one involving the use of common salt and the one for dehydrating at atmospheric temperatures, contend in varying degree with sealing problems.

At the outset at Monahans, rotating steam drums were operated for this duty but soon abandoned because of low capacity and of difficulty with scale adhering tightly to drum surfaces.

Evaporators of all kinds were considered, but were not adopted because of high initial investment, need of a substantially large boiler plant, and lack of a supply of good water for boilers. In addition to these factors, considerable sealing difficulty with such equipment was anticipated.

Common salt deposits underlie the Monahans location, but do not represent a sufficiently cheap supply for use in the process wherein sodium sulphate is precipitated preferentially.

On abandonment of the steam drums, dehydration in direct-fired unlined steel rotary-kiln equipment was practiced for about 18 months. The Glauber's salt, coming as a snow-like material from the filter in the refrigerating department and containing a total of 60 to 62 percent moisture (56 of the 60 to 62 units represented water of crystallization), was charged directly to the rotary dryer. Almost immediately the material melted to make a thin slurry, about 15 percent solids and 85 percent saturated solution or actually about 1.5 lb. water per lb. of solids. Skilled operating technique and intense firing were required to produce a dried material containing less than 0.1 percent moisture. Low fuel efficiency and high maintenance costs on equipment together with a never-ending struggle against scale particularly on the inside of the shell of the rotary kiln were factors prodding the search for an improved method.

Submerged combustion proved to be a satisfactory answer. Theoretical considerations made this method appear well suited to the task of dehydrating Glauber's salt. Some statements on submerged combustion have appeared in technical literature for 50 years or more, but no commercial equipment for evaporating large quantities of water by such means was known in 1934. In addition to demonstrating experimentally and in a pilot-plant manner the applicability of submerged combustion to this duty, considerable design and development on all parts of the equipment involved had to be done, but in November 1935, the first commercial unit was installed and has been operated approximately 98 percent of the total elapsed time since that date.

A submerged burner, lighted and suspended above a combustion tank in the Monahans plant, is shown in an accompanying illustration. The lighted burner may be lowered into the sodium sulphate solution; however, the usual operating practice is to light it when submerged by means of an igniter. Hence, ordinarily, a burner is raised from its tank only for repair or replacement purposes.

The submerged burner developed for the evaporation of sodium sulphate solutions differs in several respects from previously suggested burners of this type and hence the reasons for its success at this task. Utmost simplicity was the keynote in its development and the result was that its final construction was so simple as to be surprising to all who examined it. To arrive at this result a number of previously accepted ideas regarding submerged combustion had to be discarded, such as use of ceramic lining and of flash-back grids and constriction of burner discharge opening.

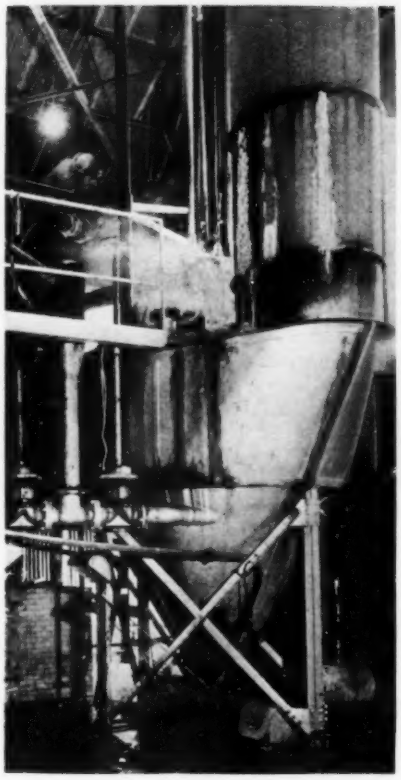
Submerged burners possessing a ceramic or refractory lining to facilitate and to complete the combustion of the fuel have been proposed and developed by some workers in this field. When combustion occurs in a small space and at velocities approaching that of flame propagation, maintainance of a flame front that will burn continuously is often difficult to accomplish. To assist in maintaining combustion and incidentally to prevent flash backs some have used a finely perforated grid in the throat of the burner. This, of course, complicated the construction and limited the flexibility as related to capacity. Proper design of the shape of the throat of the burner resulted in abandoning the use of both the ceramic lining and of the grid work. A properly dimensioned expansion chamber (the zone between the intake and the combustion part of the burner) permits maintaining a continuously functioning flame with a considerable variation in the amount

A submerged burner, lighted and suspended above a combustion tank, showing simplicity of the construction

of fuel burned. That cold metal functions satisfactorily as a burner surface has been proved. Also when theoretically sufficient air for complete burning is mixed properly with the gas before introduction into the combustion zone the combustion is as thorough as ever occurs in a high-temperature, refractory-lined firebox.

In most submerged burners described in the literature the outlet for the products of combustion has been reduced or constricted in size as compared to the cross-sectional area of the combustion zone. As advantages of this, better propagation and continuity of flame have been claimed. These gains may have some dubious value in evaporating solutions having slight or no sealing characteristics, but in the treatment of sodium sulphate solutions the tendency of the salt deposited on the burner to bridge over and close the burner discharge outweighs these considerations. When this undesirable thing is occurring, the velocity of discharge of the burned gases increases and sets up unfavorable back pressures, but in spite of this the flame is soon smothered.

By eliminating any reduction in size of the burner outlet, that is, by maintaining the same cross sectional area at the discharge as in the com-



Submerged combustion tank and associated equipment used in the sodium sulphate plant at Monahans, Texas

bustion zone the described bridging by the deposited salt is overcome. To assist in this accomplishment the burner is operated at near its maximum burning capacity so that satisfactory velocities may be maintained. Furthermore, the tendency to bridge is less as the diameter of the burner increases. Hence by making use of these several factors very successful performance is achieved in these troublesome solutions with burners, six in. and up in diameter.

Most of the heat energy released by the burner is discharged with the products of combustion into the solution but some of it is transferred through the metal wall. Intense temperatures within the burner, 2400 to 2800 deg. F. and a temperature of about 190 deg. F. in the solution in contact with the outside of the burner, represent a condition under which some sodium sulphate is precipitated as a scale on the surface of the burner. This scale insulates the metal with the result that its temperature rises rapidly; however, the scale pops off from time to time and takes with it thin layers of metal. This metal loss is greater near the burner discharge than elsewhere. The life of a burner made of common steel is equivalent to the production of about 500 tons of sodium sulphate. Burners of many different alloy compositions have been used but none to date has justified its cost in comparison with that of common steel. The iron content of the finished sodium sulphate is of the order of 0.01 percent Fe and often very much less and hence the amount contributed by the burner is nearly negligible.

The fully developed and patented submerged burner now in use in the Monahans plant appears in the accompanying illustration. The overall length is 44 in. and the inside diameter is 12 in. The burner proper is made of standard 12-in. line pipe; the swedged portion is made by cutting and welding, and the top is one-half of a standard five-in. pipe coupling. The space inside of the burner is about two cu.ft. and therein 200,000,000 B.t.u. per day or 139,000 B.t.u. per minute from natural gas may be released. Such quantities of heat per unit of combustion space are never released in usual boiler or firebox practice. For comparative purposes, a firebox serving a large rotary dryer at the Monahans plant has 141 times as much combustion space for burning the same amount of fuel and to obtain moderate operating temperatures, so as to prolong the life of this firebox a considerable quantity of excess air must be employed.

The submerged combustion tank in which the submerged burner operates is small, about eight-ft. diameter and 12 ft. overall height. During evaporation a high degree of supersaturation of the solution develops and intense scaling of the tank surfaces would be the result if it were not for the violent agitation and special features of design and materials, which this company developed over a long period of testing and research.

By reference to the flow sheet, one may follow the flows in the dehydrating circuit in the plant at Monahans. The burner in operation is suspended deep in the conical section of the submerged combustion tank and is supplied its properly proportioned natural-gas-air mixture through a large hose. The combustion gases and water vapors pass up the tank stack to the atmosphere. The sodium sulphate slurry is drawn off continuously from the bottom of the tank by means of a pump and is sent by pipe line to the settling tank. A duplicate pump on the opposite side of the submerged combustion tank is in reserve to eliminate interruptions to the operation. The density of the sodium sulphate slurry withdrawn from the burner tank is low, only about five percent solids. The cone-bottomed settling tank (5 ft. dia. x 10 ft. high) yields a practically clear overflow, part of which is returned directly to the burner tank and part of which is employed to melt the Glauber's salt from the filter in the chilling department and is then returned to the burner tank. The settling tank underflow is controlled by a rotating star valve to deliver a dense slurry containing up to 70 percent Na_2SO_4. A splitter-box below the star valve permits dividing the discharge between a continuous centrifuge circuit and a 60-ft. rotary dryer (7 ft. dia.) circuit.

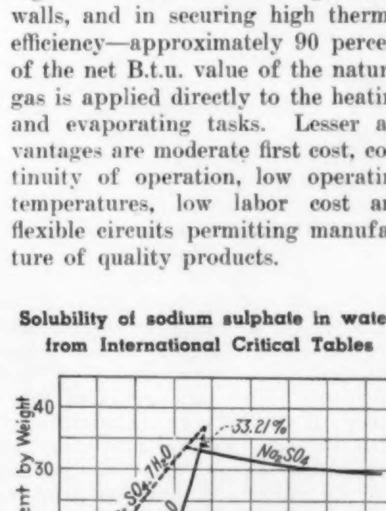
The centrifuge reduces the moisture to between five and six percent. The centrifuge filtrate is returned to the burner tank or to the large rotary dryer and dewatered cake is dried in a small rotary dryer (3x25 ft.) to a very high quality grade of anhydrous sodium sulphate with a purity of 99.9+ percent Na_2SO_4.

The dense slurry passing to the large rotary dryer is dried to a somewhat lesser quality product and is marketed as glassmakers' and papermakers' salt cake with a purity of 99.3 percent Na_2SO_4.

Since submerged combustion has been in use in the Monahans plant, about 115,000 tons of sodium sulphate have been made in the described circuits.

The most important advantages resulting from the use of submerged combustion have been in combatting successfully the scaling tendency of sodium sulphate solutions by not having to transfer heat through metal walls, and in securing high thermal efficiency—approximately 90 percent of the net B.t.u. value of the natural gas is applied directly to the heating and evaporating tasks. Lesser advantages are moderate first cost, continuity of operation, low operating temperatures, low labor cost and flexible circuits permitting manufacture of quality products.

Solubility of sodium sulphate in water, from International Critical Tables



Chem & Met PLANT NOTEBOOK

Timesaving Ideas for Engineers

STEAM ENGINE PERFORMANCE SHOWS SAVINGS IN POWER COSTS FOR PROCESS PLANTS

F. J. VONACHEN Troy Engine & Machine Co., Troy, Pa.

In a recent survey of plant power costs, nine out of 23 installations investigated were in the chemical process industries. These nine surveys covered steam engine drives for pumps, large rolls, blowers, forced draft fans, refrigeration compressors and stokers. In these installations the average power cost was shown to be 0.4 cents per kilowatt-hour. This extremely low cost was found to average 61 percent cheaper than previous or comparative power costs obtained by other means. This high level of performance was achieved in most of the plants by having a good plant heat balance, with the steam doing double duty, first in generating power and then in yielding the remainder of its heat in carrying process heating loads. In a plant in which the power produced, and the process steam which accompanies it, are both just equal to requirements, perfect heat balance is achieved. Perfect balance is difficult to obtain in practice, but for the lowest operating cost, it is essential to come as close to the ideal as possible. Several of the plants listed in the accompanying tabulation show that perfect heat balance was not being accomplished. Even in these cases, extremely low power costs were attained.

The method of obtaining double duty from process steam by generating at a higher pressure than required for processing (and expanding this steam through a prime mover, the exhaust of which supplies the necessary process heat) is, of course, well known. What is not so well known, however, is that the advantages of such double use of steam can often be achieved through the use of modern steam engine drives. The type of prime mover selected must be one which will give the proper heat balance, even with the high back pressure which is sometimes necessary to obtain high temperature in the process. Furthermore, the type of prime mover must be adapted to the mechanical characteristics required for driving the particular type of driven machine to be used. Steam engine drive is often desirable owing to its wide, smooth, flexible and easily adjusted speed range. Steam engines are readily suited to automatic control and they are simple, reliable and require a minimum of maintenance. They can be operated even by inexperienced workmen.

An earlier article (F. J. Vonachen, *Chem. & Met.*, Dec. 1936, pp. 654–657) described some of the other features of steam engines, such as the various available means for producing oil-free exhaust for those processes permitting no oil in the exit steam. The article also described a number of installations and showed the comparative economy of these installations with other driving methods.

The recent survey uncovered additional data of similar character which are summarized in the accompanying tabulation. In each case a steam engine driven installation was compared with the comparable cost of driving the driven machine by electric motor at the power rate available.

The detailed calculations for one of the installations, namely, driving a forced draft fan for the Virginia Smelting Co., are given herewith. The engine, a 5x5E, is rated at a maximum brake horsepower of 20 at 500 r.p.m. The average brake horsepower is 11 at 500 r.p.m. and the operation based on 3,500 hr. per year, using steam at 200 lb. gage without superheat. The engine exhausts at 12 lb. gage back pressure. The boiler employs feed water at an assumed temperature of 220 deg. F., producing steam at 50 cents per 1,000 lb. The installed cost of the engine is $750, compared with that of a comparable motor for the same service of $673. No extra labor is required for operating either engine or motor. Purchased current, including demand charges, costs 2 cents per kilowatt-hour. All of the engine exhaust is used for heating and process work.

For figuring the annual cost of owning and operating the engine, the following data are available: depreciation at 5 percent of $750 amounts to $37.50, and average interest at 6 percent over the life of the equipment (750 × 0.0315) equals $23.60. Maintenance at 2 percent amounts to $15 annually. For an average engine load of 11 b. hp., hourly steam consumption is 590 lb. It is calculated that 91.5 percent of the heat is left in the exhaust, so that 8.5 percent of the steam cost, amounting to $87.70 per year, is all that is chargeable to the engine. Engine lubrication, at $45.80 per year, makes up the final item of engine operating cost, since no extra cost for labor is involved. The total of these figures comes to $209.60 per year.

Comparing the cost of driving the fan by motor, rather than by engine, the following data are available: depreciation, at 5 percent of $673, amounts to $33.65 per year. Average interest at 6 percent, figured on the life of the equipment (673 × 0.0345) comes to $21.20. Maintenance, again taken at 2 percent, amounts to $13.46. The power requirement of 34,650 kw.hr. per year, at 2 cents per kilowatt-hour, gives an annual power cost of $693. Lubrication cost at $1.14 is the final item, since extra labor is not required. The total annual cost of motor drive, then, can be taken at $762.45.

As shown by these calculations, the annual saving through use of the engine drive amounts to $552.85, which will pay for the extra cost of the engine in less than two months and give a yearly return on the extra investment of 720 percent. This saving will also pay for the entire engine cost in less than 17 months. As shown by the figures, power cost using the engine amounts to but 0.604 cents per kilowatt-hour, compared with a cost at the electric motor shaft of 2.2 cents per kilowatt-hour. Engine power, therefore, is shown to be 72 percent cheaper.

Summary of Data Comparing Engine and Motor Drive

Plant	Engine Used on	Percent Exhaust Steam to Heating or Process	Engine Cost Installed, Dollars	Annual Saving, Dollars	Months to Pay for Extra Cost of Engine	Percent Yearly Return on Extra Investment	Engine Drive Power Cost, Cents per Kw.-Hr.	Percent Saving in Engine Power Cost
Large oil refinery	Rotary pump	60	2,034	1,006	12	102	0.485	42
Colgate-Palmolive Peet Co.	Large rolls	85	1,930	360	48	25	0.63	37
Large oil refinery	Pump	100	2,206	336	(2)	(2)	0.422	47
Large oil refinery	Blower	100	3,616	6,942	4	360	0.252	86
Virginia Smelting Co.	Forced draft fan	100	750	553	2	720	0.604	72
Chemical plant	Blower	None	1,980	7,147	2	770	0.06	96
Buckeye Brewing Co.	Refrig. compressor	60	3,406	(1)	(1)	(1)	0.475	(1)
Paper plant	Stoker	100	508	254	3	590	0.47	67
Oil refinery	Oil pump	50	4,105	9,050	(2)	(2)	0.204	80

[1] Comparative power cost not available. [2] Engine lower in first cost.

Machinery, Materials and Products

Chem & Met Process Equipment NEWS

Power Shovel

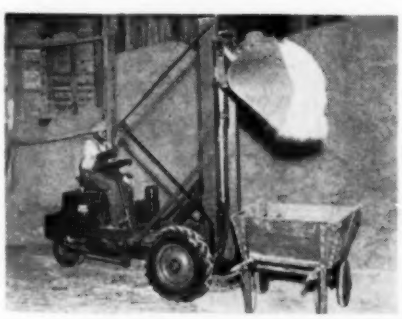
HANDLING of bulk materials such as fertilizers is the function of a new gasoline-powered mechanical shovel designed for 24 hour continuous operation and built by the Clark Tructractor Division of Clark Equipment Co., Battle Creek, Mich. The machine is powered by a four-cylinder gasoline engine and carries a load of 1,500 lb., bulking as much as 18 cu.ft., at from 3½ to 11 m.p.h. The load can be lifted in less than ten seconds and dumped into carts, trucks or bins. All operations are controlled by the driver without dismounting. Underwriting agencies have approved the shovel from the standpoint of fire hazards.

Vibrating Screen

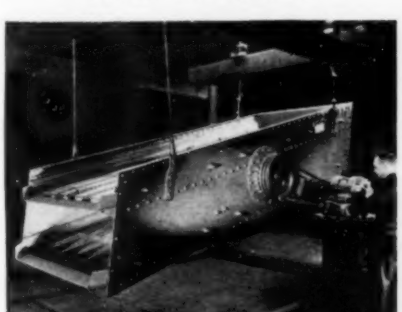
FOR SCREENING heavy granular materials such as coal, chemicals, stone and ore, the crushing and cement division of Allis-Chalmers Mfg. Co., Milwaukee, Wis., has introduced a new type of vibrating screen known as the Ripl-Flo. The screen is said to employ a new principle of operation, giving it particularly smooth operating characteristics and high capacity. The operating member is an eccentric shaft carried on large anti-friction bearings and supporting a pair of counterweighted flywheels, one of which serves also as the sheave for the Texrope drive. The eccentric shaft provides most of the force causing the screen body to gyrate in a rapid circular motion. Fine adjustments for balance are made by means of the flywheels. The new feature is that the flywheels themselves do not gyrate since the shaft is so turned that their center of rotation coincides with the center of gyration of the screen body. Driving power is said, therefore, to be exceptionally low. As shown in the illustration, the screen is of the inclined type, supported by cables. Floor mounting, however, can be used. Single and double deck types are built in sizes to 6 ft. by 14 ft.

The milling division of this company has announced a new type of vertical hammer mill with nearly 100 percent screen area. Having a new type of hammer, the mill is said to have large capacity per horsepower and to generate little heat. Sizes range from 25 to 150 hp. Compact design is achieved by mounting the motor beneath the machine, away from the flow of product, thus reducing possible fire hazard. The main shaft anti-friction bearings are lubricated by a small motor-driven pump. A separate motor-driven fan discharges the product to a conical dust collector.

Power shovel handling fertilizer



Ripl-Flo vibrating screen



Dispersion Dryer

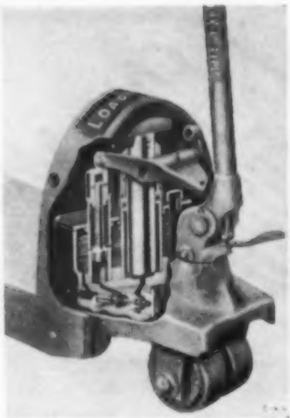
FOR THE DRYING of wet materials ranging from filter and centrifugal cakes to slimes, pulps and other colloids which cannot be filtered, Western Precipitation Corp., Los Angeles, Calif., has developed the new Turbulaire dispersion dryer in which the wet material, mixed with partially dried material, and in some cases with completely dried material, is dried in suspension in a hot stream of air or combustion gases. The raw material enters a pug mill where it is mixed with partially dried material, separated from that which has been dried, by means of an impact separator. Sometimes part of the fully dried material is also added at this point. The mixture is then fed by the pug mill to the dryer in which the wet semi-solid is internally circulated by mechanical means in contact with the heated drying medium. Here drying takes place in agitated suspension, after which partially dried oversized particles are thrown down in the impact separator for return to the pug mill.

Completely dried material is separated in a Multiclone multiple cyclone separator from which the conveying gas discharges, together with 1–3 micron particles, to the atmosphere or to a bag filter. The drying medium may be hot air or the combustion gases from a gas-, oil- or coal-fired furnace, diluted with fresh air or air recirculated from the dryer vent to the desired inlet temperature of from 200 to 1,200 deg. F. Rapid drying action is said to yield a cool product. Exceptionally high thermal efficiency is claimed, with heat requirements from 1,600 to 2,500 B.t.u. per pound of water evaporated. Electrical consumption is said to range from 15 to 25 kw. per 1,000 lb. of water evaporated, depending on the size of unit. Turbulaire dryers are available in sizes from 75 to 4,000 lb. of water evaporation per hour. Installation costs range from $30 to $6 per pound per hour of evaporation, depending on size.

Dryer installation showing Turbulaire and direct-fired air heater

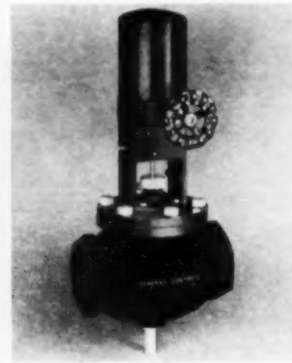
Rotary Pressure Joint

MODIFIED CONSTRUCTION, said to reduce maintenance costs and simplify upkeep on the larger sizes of rotary pressure joints of its manufacture, has been introduced in the new Type R joint made by the Johnson Corp., Three Rivers, Mich. The operating principle of this joint, as described on page 161 of our March 1935 issue, has not been changed in any way. In older designs, however, the wearing plate at one end of the joint was renewable, whereas the wearing plate at the other was part of the body casting. In the new Type R, both wearing plates are removable and renewable and can both be furnished in bronze, to provide the equivalent of all-bronze construction, for much less than actual all-bronze cost. The new construction was found desirable because in larger joints operating at slower speeds and higher pres-

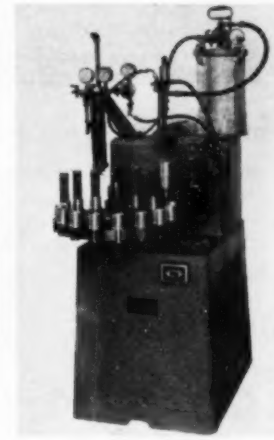


Hydraulic lift mechanism

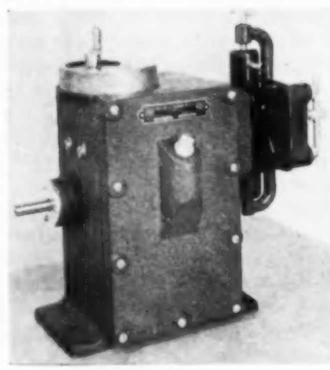
Recorder with tear-off device



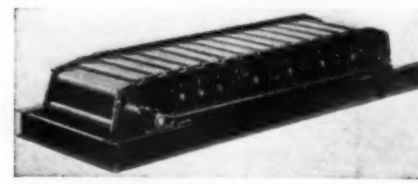
Manual-reset solenoid valve



Coating machine for container interiors



Small proportioning pump



Manganese steel feeder

sures, full advantage cannot be taken of the wiping action on the sealing surfaces which occurs in smaller joint installations. Leaks due to dirt and scale accumulating under the sealing ring might therefore result in steam cutting of the casting. The new construction is available in joints for pipe sizes from 3 to 6 in., for working pressures to 150 lb.

Hand Lift Truck

Two RECENT DEVELOPMENTS in hand lift trucks have been announced by the Philadelphia Division of the Yale & Towne Mfg. Co., Philadelphia, Pa. A new version of the company's single-stroke Blue Streak hand truck for loads up to 2,500 lb. features several refinements, including 180-deg. steer and lifting with a shorter handle stroke, at any point within a 90-deg. arc. The handle automatically disengages when the load is fully lifted, thus providing a free handle.

A new development with this company is the Load King hydraulic hand lift truck, made in capacities from 3,500 to 8,000 lb. The new truck is claimed to require approximately two-thirds of the lifting effort usual to this type of equipment. Greater safety and lower maintenance, coupled with controlled lowering of the load are other features. The hydraulic unit is self-contained and fully inclosed, as shown in the accompanying illustration. The truck itself has been reduced to essentials through careful design.

Chart Tear-Off

So THAT each day's strip-chart record of such functions as temperature, pH, etc., may be torn off and filed, Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, Pa., has developed a new tear-off device made to fit all of this company's Micromax strip-chart recorders built since 1936. Thus daily records may be filed as readily as round-chart records. With the new tear-off device, no time is wasted and it is not necessary to re-thread the chart through the guide.

Solenoid Valve

SERIES MR-1-2 is the designation of a new manual-reset valve for water, air, gas, steam and oil, now being offered by General Controls Co., 801 Allen Ave., Glendale, Calif. Upon current failure, the valve closes and cannot be reopened until current is available and the valve is manually reset. The valve cannot be held open in any way without restoration of the current. An external magnetic operator is employed, removed from the heat and corrosive influences of the fluid handled. The unit may be operated from a dry cell or from a d.c. circuit; or from an a.c. circuit through use of an integral rectifier. Sizes range from ½ to 6 in., with screwed or flanged bodies, made in iron with bronze trim, or special alloy body and trim. Explosion-proof types are obtainable.

Proportioning Pump

DESIGNED for use in hypochlorination of small water supplies and as a reagent feeder for a variety of chemical solutions, a new small proportioning pump has been announced by Wallace & Tiernan Co., Newark, N. J. This machine, a belt-driven model, has been designed to deliver 60 gal. of solution in 24 hours against a back pressure of 30 lb. per sq. in. when operated at 720 r.p.m. Adjustment by means of a crank arrangement gives a range of capacities of 4 to 1 at constant shaft speed. The solution being pumped comes in contact only with materials such as hard rubber, silver and glass, making it suitable for handling, in addition to hypochlorite, such materials as caustic soda, copper sulphate, various acids, iron salts, etc.

Container Coater

A MACHINE designed to apply sprayed lacquers or other protective coatings inside collapsible tubes, cans or other metal containers, at the rate of 40 to 50 per minute, has been developed by the F. J. Stokes Machine Co., Philadelphia, Pa. Sixteen holders are provided for the containers which, as they are rotated into spraying positions, automatically control their own coating operation so as to avoid waste of material if a position is left empty. The containers are each lifted in turn to bring the spray nozzle to a suitable distance from the bottom, the control of the spray being adjustable and arranged to apply the coating either as the nozzle enters or withdraws. Double coating may also be accomplished. Uniformity of film is secured by rotating the containers at a high speed during coating.

Heavy Duty Feeder

A LINE OF manganese steel apron feeders for handling large tonnages of heavy materials has been introduced under the name of Robins Oro by Robins Conveying Belt Co., Passaic, N. J. The apron consists of a series of double-beaded overlapping and interlocking pans heavily ribbed to withstand impact pressures. Vertical overlapping side flanges are claimed to

eliminate spillage. Integral cast links beneath the pans serve as chain links. The upper strand of the apron is carried on wide, straight-faced solid rollers spaced to provide proper support to meet the conditions at various points in the run. The feeder will operate up to a 16-deg. slope. Depending on pitch, various widths from 24 to 96 in. are available.

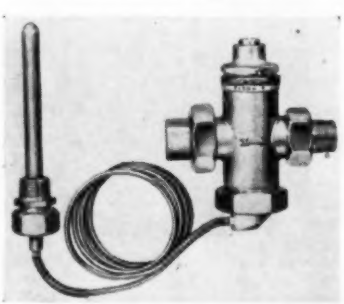
Temperature Regulator

A NEW thermostatic valve for regulating the flow of steam or water in heating operations has been developed by Sterling, Inc., 3692 North Holton St., Milwaukee, Wis. The new valve, which is made for pressures of 0 to 30 lb. and 0 to 125 lb. in sizes from ½ to 1 in., is available in a variety of temperature ranges between 70 and 270 deg. F. The valve is of the direct-acting type, closing on rise in temperature. The design gives a modulating control of the heating fluid, and is said to control within 1½ deg. F., plus or minus. Pressure produced in the thermometer bulb is communicated to the valve-operating mechanism which is a bellows loaded by an adjusting spring. The standard thermometer bulb is of copper, but protective sleeves are available in various special construction materials to meet corrosion resisting requirements.

Vertical Motor

EXPLOSION-PROOF motors of vertical construction, suitable for Class I, Group D, and Class II, Group G locations, have been announced by U. S. Electrical Motors, Inc., 200 East Slauson Ave., Los Angeles, Calif., and 80–34th St., Brooklyn, N. Y. The classes of use comprise atmosphere containing such materials as flammable volatile liquids and gases, as well as combustible dusts. The new motors are fan-cooled and are asbestos protected for a 55 deg. C. temperature rise. A variety of mounting flanges is available to fit practically any type of application without additional adapters.

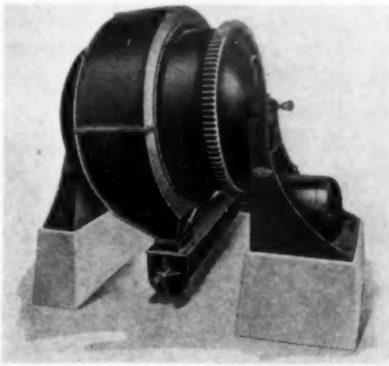
Direct-acting regulator



Stainless Ball Mill

SPECIAL CONSTRUCTION to prevent possible contamination of the material ground is evident in a new stainless steel ball mill recently built by Abbé Engineering Co., 50 Church St., New York, N. Y. The mill is intended particularly for grinding various types of resins for molding compounds. The cylinder is made of stainless-clad steel, welded to stainless-clad heads. The interior surface of the cylinder has rounded baffle bars welded to it to produce a wave-like interior and give the required cascading action. The mill may be jacketed for cooling or heating, with rotary joints at the trunnions for introducing and discharging the cooling or heating medium. An all-stainless steel housing surrounding the mill is provided for discharge. If necessary, a connection through the trunnion can be provided for vacuum or the addition of process liquids or gases. The geared head motor drive is of the inching type with brake for stopping and holding the cylinder at the desired position.

Stainless steel ball mill



High-Strength Bus

FOR USE in industries having equipment requiring large amounts of power, such as large electric furnaces, Delta-Star Electric Co., 2400 Block, Fulton St., Chicago, Ill., has developed a new method of bus installation designed to withstand severe short-circuited stresses. As shown in the accompanying view, this construction employs a reinforced bus structure with insulators always in compression, their strongest position. Heavy U-shaped steel channels bolted to base plates carry the porcelain insulators which have expansion type conductor clamps equipped with rollers and springs to permit free longitudinal bar movement. Conductors may be rectangular bars, channels or square tubes.

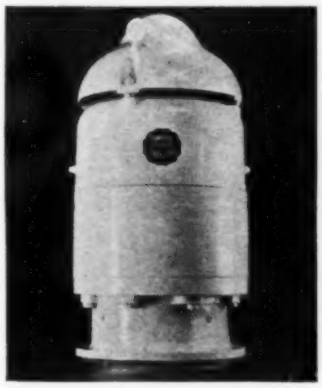
Vertical Pump

AN ACCOMPANYING VIEW shows a new vertical centrifugal pump of 3-in. size recently announced by Lawrence Machine & Pump Corp., 371 Market St., Lawrence, Mass. The pump employs a top suction which is said to prevent air binding and thus makes the pump suitable for volatile liquids. Provided there is a slight head on the suction, irregular and intermittent flow can be handled. The pump is uninjured by running dry. Its stuffing box is subjected only to the actual pressure or head on the pump suction. Various sizes and various materials adapted to the particular service are available. A non-clogging type impeller may be supplied.

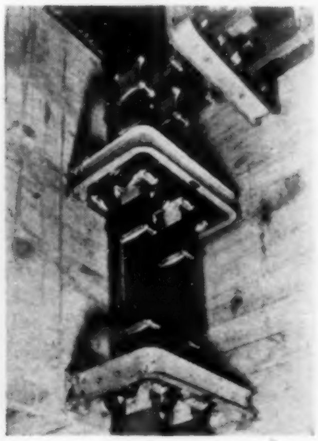
Fractionating Pump

AN ACCOMPANYING ILLUSTRATION portrays a new all-metal fractionating pump, designated as Type MC-275, which has recently been announced by Distillation Products, Inc., Rochester,

New vertical explosion-proof motor

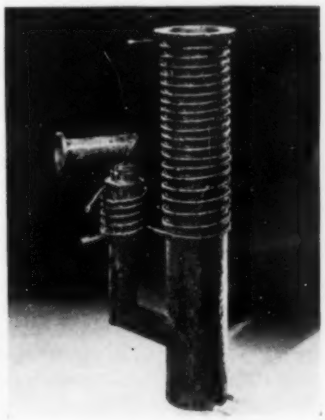


New bus installation



Vertical centrifugal pump

Metal fractionating pump for high vacuum



N. Y. The new pump, which uses special rugged esters as pumping fluid, gives extremely high speeds up to 300 liters per second in the range from 10^{-3} to 10^{-5} mm. of mercury. The rating of ultimate vacuum is 6×10^{-6} mm. The pump is therefore recommended for such high vacuum applications as mirror coating, lens coating, ultra-centrifuges, and cyclotrons. All-metal construction gives a more rugged unit than the glass-metal type ordinarily used.

Equipment Briefs

DESIGNED for water filtration, the new Model CPHLS radial fin filter announced by Staynew Filter Corp., Rochester, N. Y., employs a type of construction similar to the type previously built by this company for use on air transmission lines and internal combustion engines. All water passes through a special fabric filter medium supported on radial fins in such a fashion that a filter element only 11 in. high by 8½ in. in diameter possesses an active filter area of 1,325 sq.in. The unit may be arranged either to be cleaned by removing, or by backwashing with clean water.

A NEW smaller pipe heating system for maintaining the fluidity of viscous liquids, such as bituminous materials and heavy fuel oils, has been announced by Albert G. Purdue Associates, 303 Wooster St., New Haven, Conn. This equipment is similar in principle to the larger Lines Thermal Electric Conduction System announced on page 437 of our July 1939 issue. The new Junior system is smaller, has a transformer rated at 2 kv.a. (or half that of the larger unit) and is available at a considerable reduction in cost. The heat capacity of the new unit is not sufficient to heat the liquid initially, but only to prevent heat losses during passage through the line. Therefore, an auxiliary heat source must be provided for initial heating. In this system, a low-voltage, high-amperage transformer is used to provide current which is passed through the steel pipe line. Overcoming resistance of the line provides the necessary heat. The system includes a thermostat, special tank element head, an insulating flange and necessary connectors.

SIZES from 600 to 4,000 hp. are available in a new line of steam-engine-driven angle compressors announced by Clark Bros. Co., 602 Lincoln Ave., Olean, N. Y. The new compressors are similar in design to this company's right-angle design of gas-engine-driven compressors. Compressors are built in from three to six power cylinders, with a corresponding number of compressor cylinders. Uniflow steam cylinders are used for economy. Features claimed are small floor space requirements, low foundation and building costs.

PLEXIGLAS, a clear, transparent plastic made by Rohm & Haas Co., is being employed in the fabrication of the liquid end of a new proportioning pump for dilute acids, hypochlorite and other chemicals, which is made by Milton Roy Pump Co., 310 East Mermaid Ave., Philadelphia, Pa. Pumps of this type are made in capacities from ½ to 20 gal. per hour. The plastic construction permits viewing the flow of liquid and the movement of valve checks and pump piston.

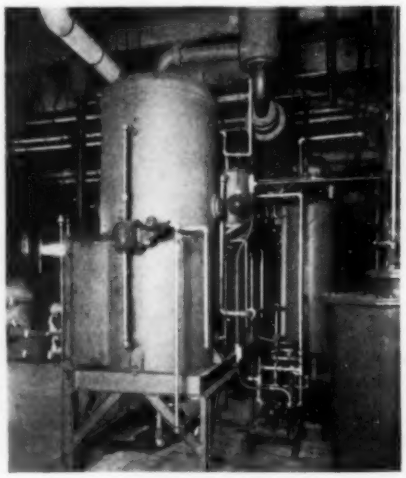
O'DONNELL SHOE Co., Humboldt, Tenn., has developed a new line of shoes with conductive soles for the purpose of preventing accumulation of static electricity on the human body. Such shoes are intended primarily for use in the manufacturing and handling of flammable and explosive materials such as solvents and explosives.

Pre-Set Controller

ADDITION to its line of air-operated temperature controllers of a throttling type known as the Pre-Set Free-Vane temperature controller has been announced by the Bristol Company, Waterbury, Conn. The new instrument was developed for use on processes which show a tendency for the temperature to exceed the control setting of the instrument on the initial rise. This is particularly prevalent in batch processes where there is a slow rate of circulation of the cooling medium as in jacketed cooling units. The new controller introduces a pre-setting effect proportional to the width of the throttling range and also to the rate of change of the condition being controlled. This action occurs prior to or during the approach of the pen to the control point, so as to decrease the rate of approach of the temperature to the control point. A wide range of adjustability of this feature is provided. A type of application successfully handled by this controller, according to the manufacturer, is in the shredding of alkali cellulose for rayon and cellophane manufacture.

Multiple-Effect Water Still

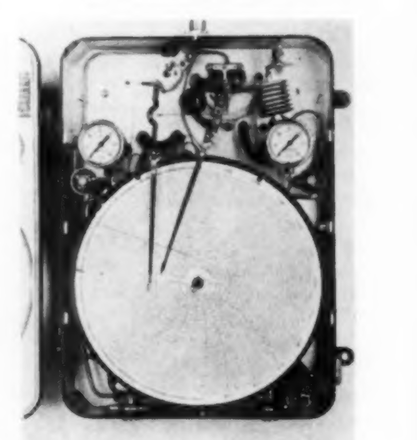
One of several multiple-effect water stills recently built and installed by the F. J. Stokes Machine Co., Philadelphia, Pa., is the one shown here which was built for Sharp & Dohme, Philadelphia pharmaceutical manufacturers. This still, having a capacity of 300 gal. per hour, is said to deliver water with less than 3–5 parts per million of total solids. Owing to the efficiency of multiple-effect equipment of this type as compared with single effect, it is stated that multiple-effect stills will usually save their entire cost in two years or less.



Drum Filling Valve

TO FACILITATE filling drums by weight, for all sizes of container from 5 gal. upward, the Volumeter Co., Wilbury Place, Buffalo, N. Y., has developed a new automatic valve which can readily be attached to any beam scale. This valve is electrically controlled, operating from a light socket and requiring no special technique or tools for installing. It is claimed by the manufacturer that the valve is constructed to handle any liquid that will flow through a pipeline, regardless of temperature or corrosive conditions. Its accuracy is said not to be affected by air, vapors, sediment or scale in the pipe line. Claimed to be as accurate as the scale to which it is attached, it is said to be valuable also from a safety standpoint in that it permits filling operations without danger of splashing the operator.

Pre-set Free-Vane temperature controller



Automatic drum filling valve

Check

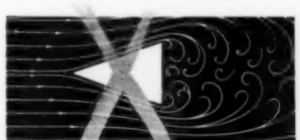
EVERY ONE OF THESE VALVE *Benefits* IN YOUR OWN PLANT . . .

- maximum capacity when needed most
- accurate pressure control under toughest working conditions
- trouble-free service
- smooth operation
- tight closure
- accurate regulation
- speedier production results
- elimination of failures
- constant delivery pressure
- cost saving operation
- no service attention
- no spoilage
- practically zero in maintenance costs

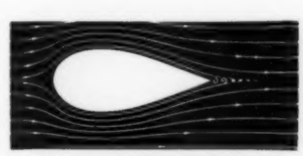
CASH STANDARD *Streamlined* TYPE 1000 PRESSURE REDUCING VALVE

It costs you nothing to check up on these benefits

Put a CASH STANDARD Streamlined Type 1000 Valve to the test for 30 days — you can do it FREE — find out what its performance means in dollars and cents savings — see how flow, that is not broken up by valve stems, springs, or other parts, adds immeasurably to better all around results — after 30 days a bill is sent to you — you either pay the bill or return the valve to us at our expense. Putting this test off may be losing valve money for you.



NONE OF THIS TURBULENCE



GIVES THIS FLOW PATTERN

If you want full details on the STREAMLINED "1000" Valve, send for bulletin 1000.

This bulletin gives you complete design and operating facts. Steam, air, and water capacity charts are shown —they enable you to determine precisely how much fluid any size Streamlined Valve will deliver under your exact pressure conditions—for steam, air (and other gases), water (and other liquids).

Straight Line Flow

FROM INLET TO OUTLET

A. W. CASH COMPANY

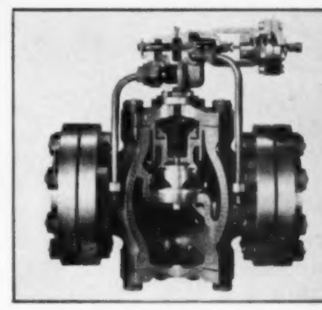
CASH STANDARD

CONTROLS VALVES

A CASH STANDARD "GET ACQUAINTED" COLUMN

Question: "Don't you people make anything besides that Streamlined Valve you talk about so much?"

Answer: "Yes Sir; we do! And we propose to picture one or two of them here each time."



Cash Standard Type 11 Regulator, for use with water, air or any gas or oil that is non-corrosive. Pressure to actuate pilot valve may come from any source; and be as high as 1500 lbs. Variety of uses, notably as condenser water regulator.

Inlet pressure up to 600 lbs.; outlet pressure up to 250 lbs. Bodies; iron, bronze, steel. Trims; iron, bronze, stainless steel. Screwed, flanged, or ammonia type ends. Sizes: 2" to 12".

Cash Standard Type 8871 Pressure Reducing Valve; for use with liquids — especially dirty liquids, like Bunker C fuel oil for example. No sliding fits: inner valve bolted to diaphragm for positive movement.

Initial pressure up to 250 lbs., reduced pressure up to 200 lbs. Bodies; iron, bronze or steel. Renewable inner valve and seat ring, stainless steel. Sizes: ½", ¾", 1".

Get Free Bulletins on Above . . . Write to A. W. CASH COMPANY

Sulphuric Acid From Refinery Sludge

INTERESTING PROGRESS has been made in the past few years in the recovery of sulphuric acid from waste oil refinery sludges. Before the development of the patented Chemico sludge conversion process, acid sludges were hydrolized with water and steam to effect a separation into oil and weak acid after which the acid was concentrated for reuse. This method was wasteful and unsatisfactory because the separation was never entirely complete, but resulted in an impure black separated acid which could not be concentrated to the high strength necessary for some uses.

An entirely different principle of recovery is now in use. When acid sludge is heated to about 550° F it decomposes into sulphur dioxide gas, solid coke, water vapor and a small quantity of hydrocarbon vapor. The advantage of this method is immediately obvious since the sulphur dioxide gas can be processed in a contact sulphuric acid plant to clean sulphuric acid of any desired strength.

The accompanying illustrated flow diagram is typical of the latest practice in acid sludge recovery and is based on a plant erected recently at the Bayway Refinery of the Standard Oil Company of New Jersey.

The process as originally developed called for the use of hot combustion gases to heat the sludge by direct contact. A novel and far more satisfactory method is now employed. The granular coke resulting from the decomposition of the acid sludge is fed in regulated quantity into a rotary kiln where it is ignited and discharged at red heat into a second and smaller kiln by means of a sealed plunger feeder. The heat content of the coke is transferred to the sludge which is fed into this second kiln in a measured and continuous stream and the breakdown reaction is quickly completed. The strong gas from the decomposition kiln is cooled to condense out moisture and condensable oil and then passed through a furnace where any fixed non-condensable hydrocarbon gases are burned out. The gas is then cooled, dried and processed in a modern contact acid plant using vanadium catalyst. The coke resulting from the decomposition of the sludge leaves the decomposing kiln with the circulating coke and is returned to the heating kiln after the excess has been diverted for use elsewhere as fuel.

CHEMICAL & METALLURGICAL ENGINEERING

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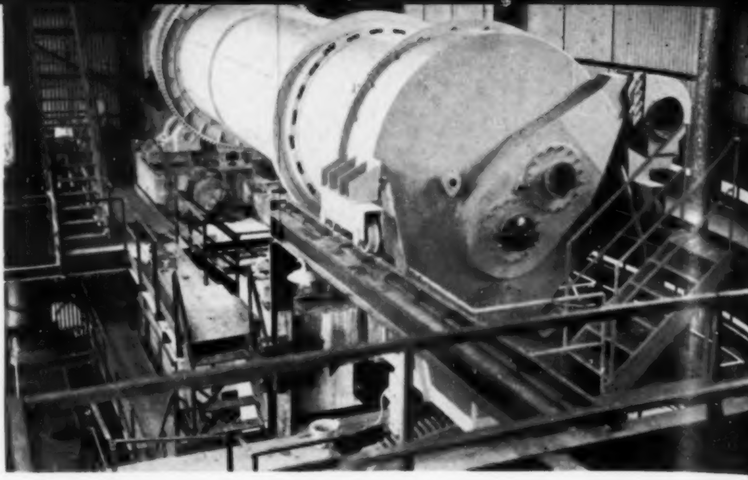
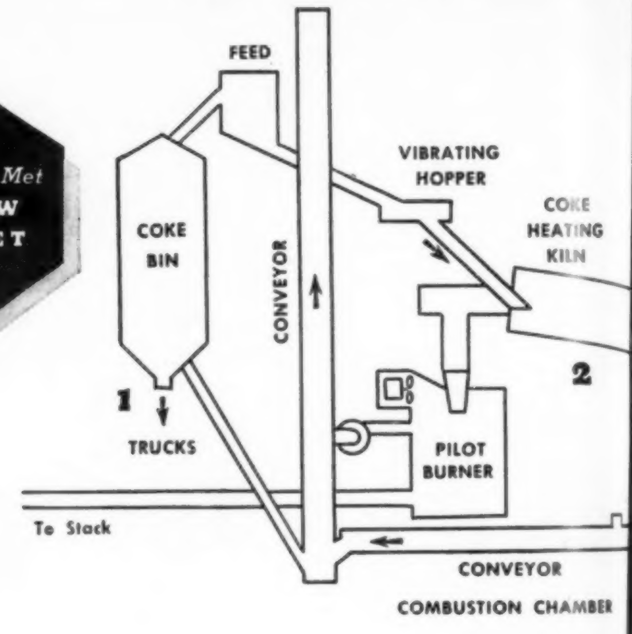


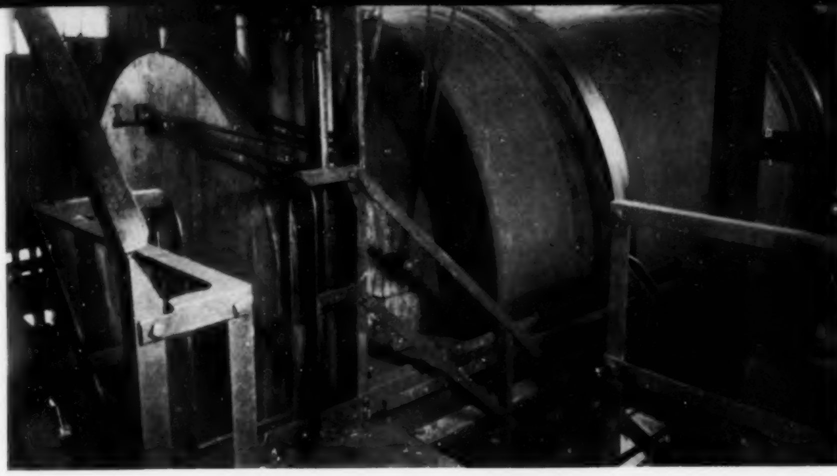
2 Coke heating kiln. Granular coke brought to red heat by combustion of volatile matter, transfers its heat to the sludge in the decomposing kiln

A *Chem & Met* **FLOW SHEET**

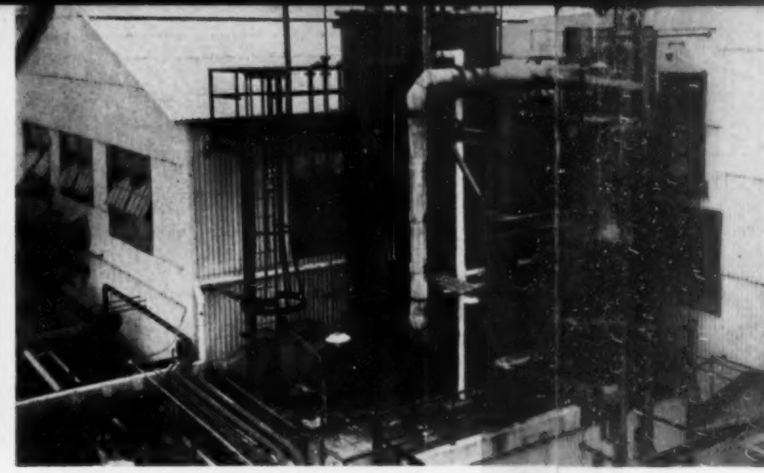


1 Coke receiving bin. Byproduct coke resulting from the decomposition of the sludge is collected in this overflow bin

stion of
g kiln

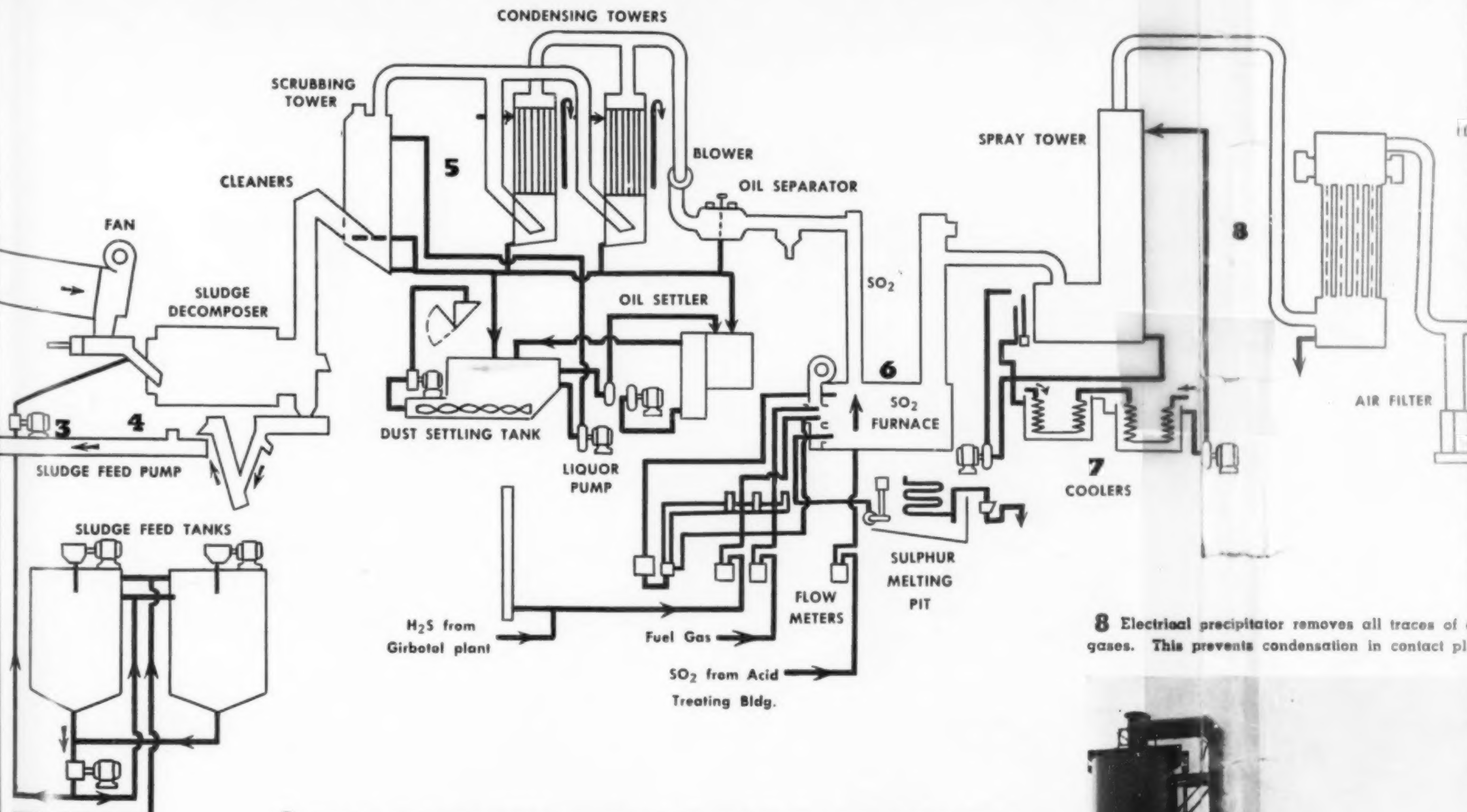


4 The sludge is decomposed in a rotary kiln by the admixture of hot granular coke from the heating kiln

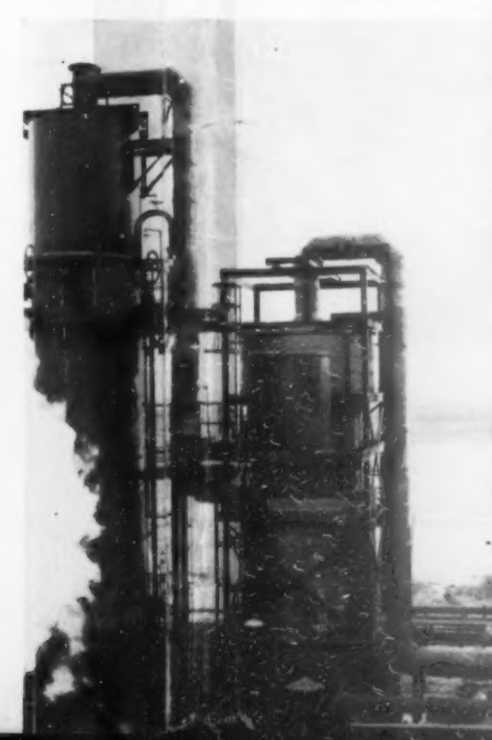


5 Cold water circulated over spray towers cools the gas and condenses the steam and condensible hydrocarbons

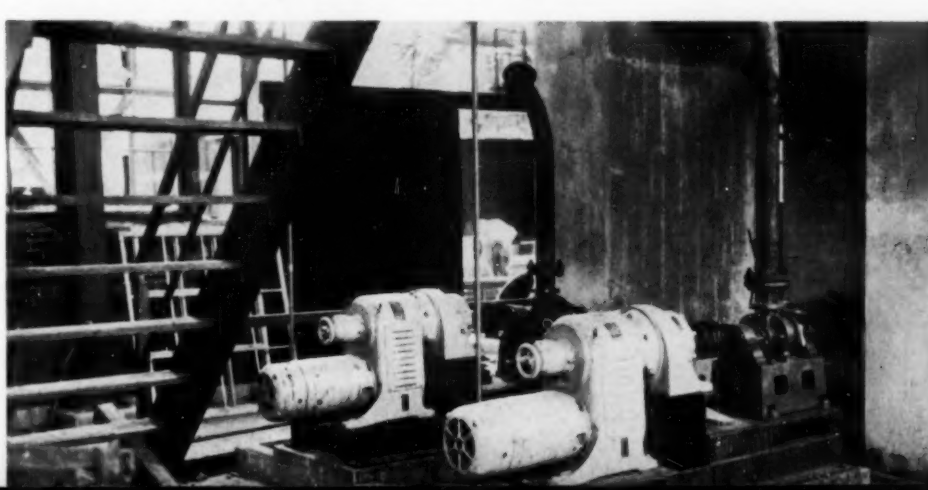
6 nace

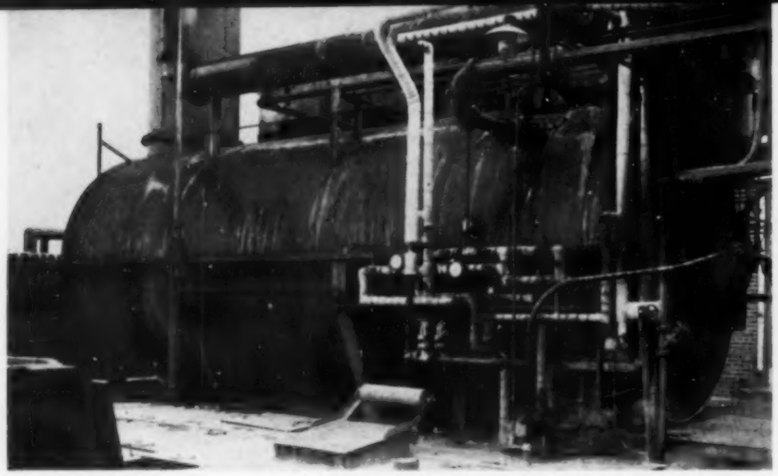


8 Electrical precipitator removes all traces of a gases. This prevents condensation in contact pla



3 Variable speed sludge pumps, connected through speed reducing gears to electric motors, regulate the flow of sludge to the decomposing kiln

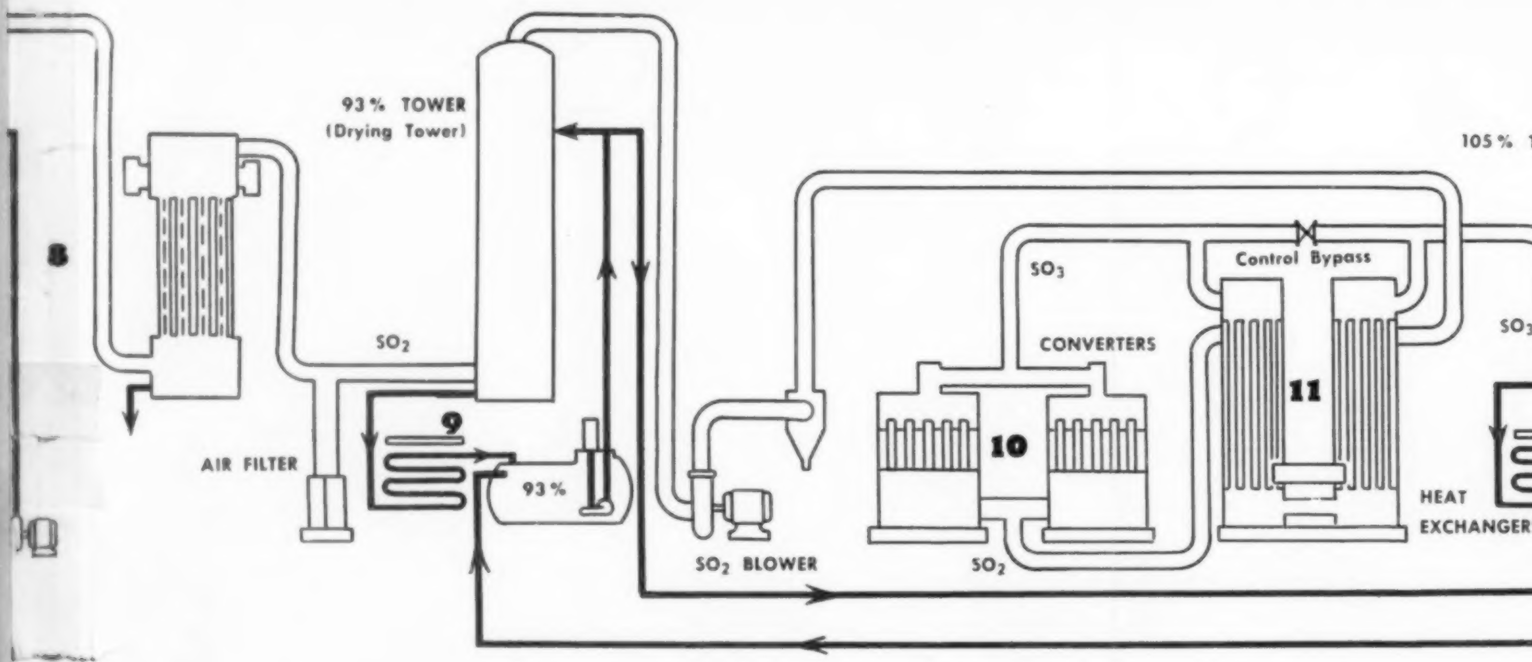




e gas and condenses

6 Byproducts hydrogen sulphide and brimstone are burned in this furnace to provide additional SO_2 gas for the production of make-up acid

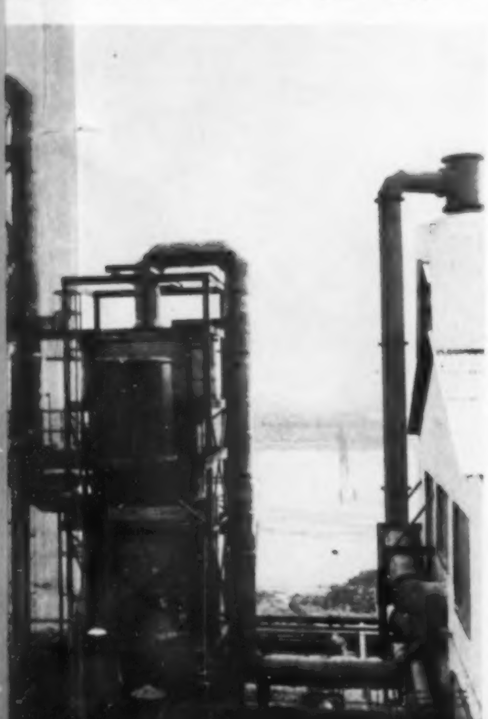
7 Cold water in submerged coils cools the liq
Accumulated condensate is bled off at high te

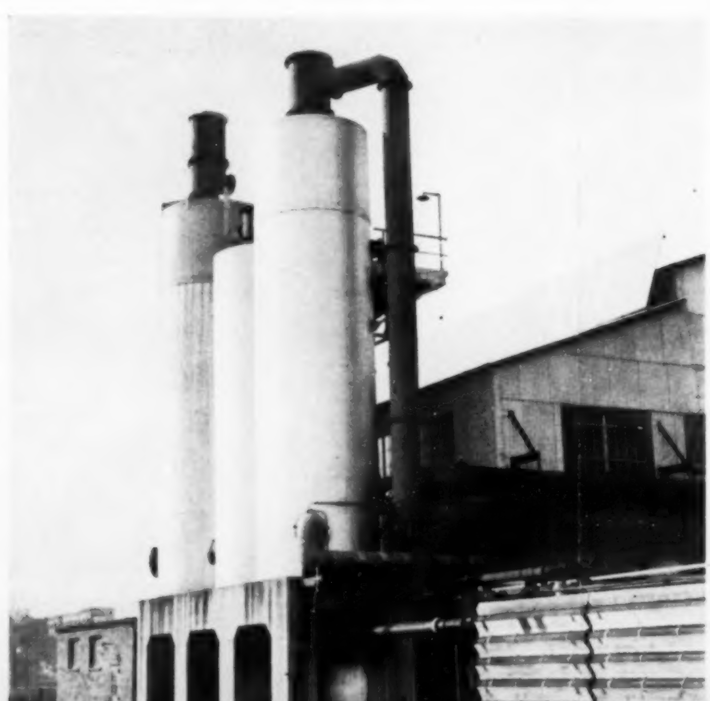


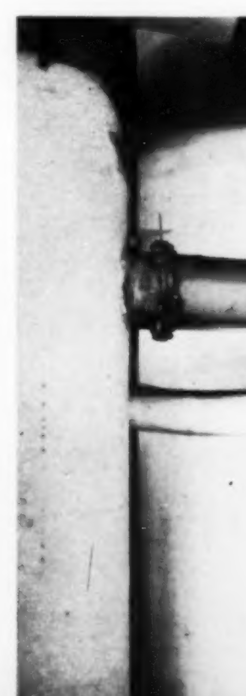
precipitator removes all traces of acid mist from
revents condensation in contact plant equipment

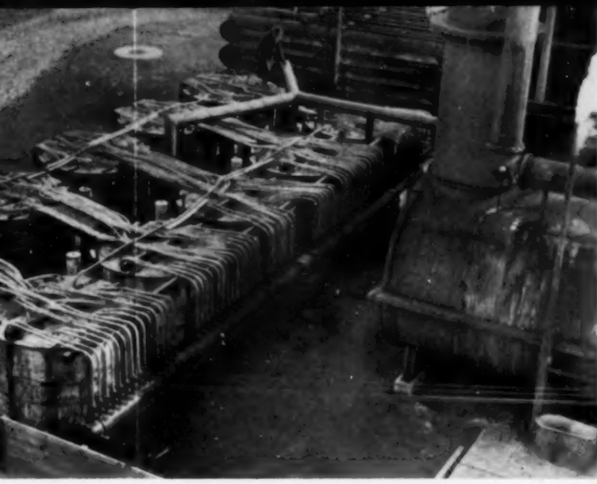
9 Strong acid circulated over the tower in foreground dries the gas before it enters the converters

11 Heat exchangers
verters is heated by the

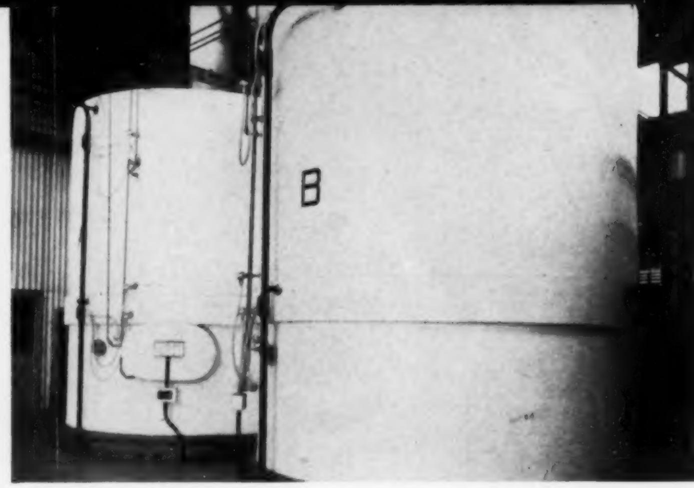




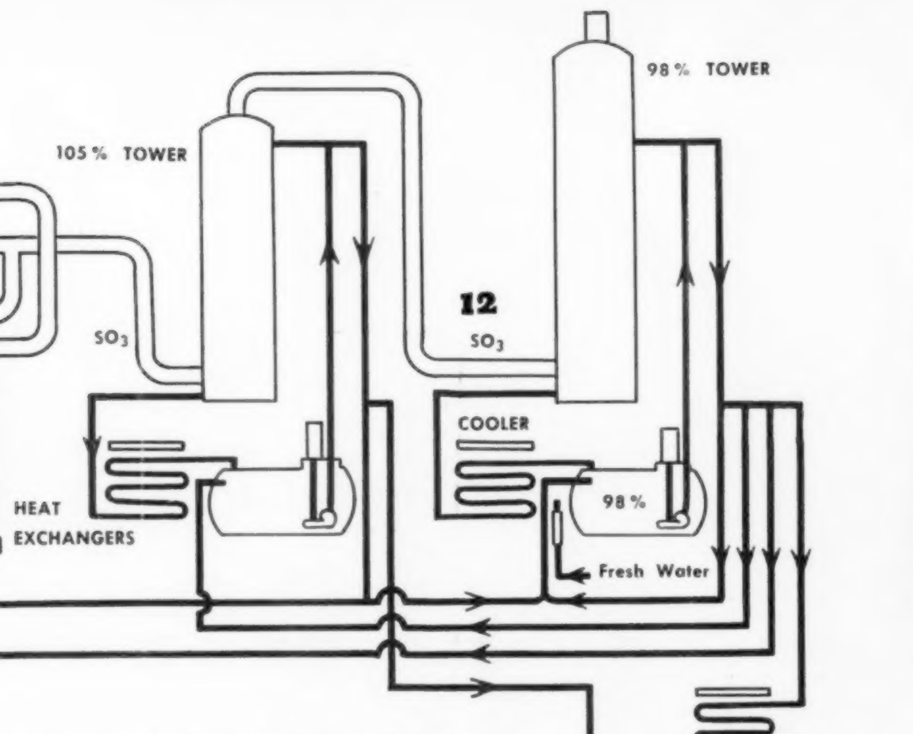


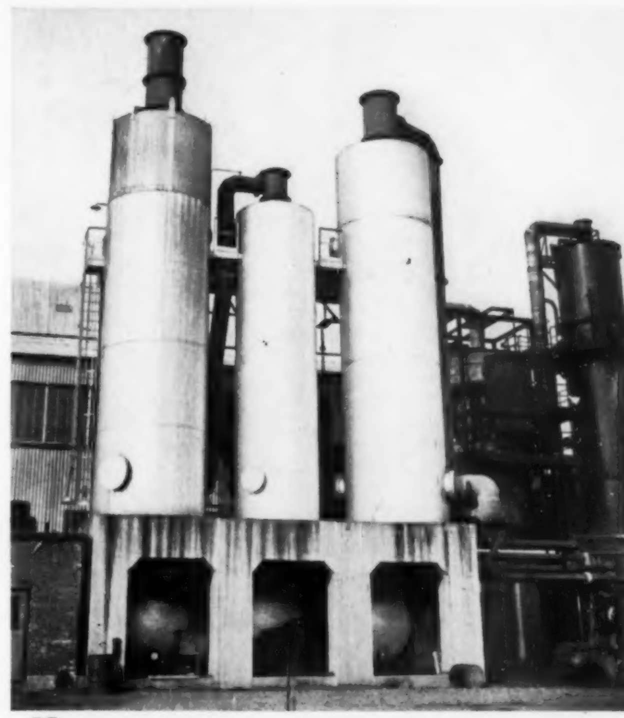


s cools the liquor which is pumped again to the spray tower. off at high temperature to prevent loss of SO_2



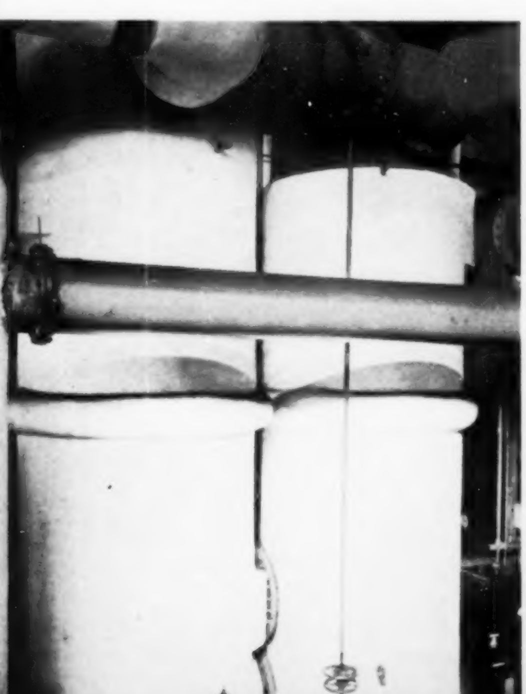
10 Sulphur dioxide and oxygen combine to form sulphur trioxide in converters charged with vanadium catalyst

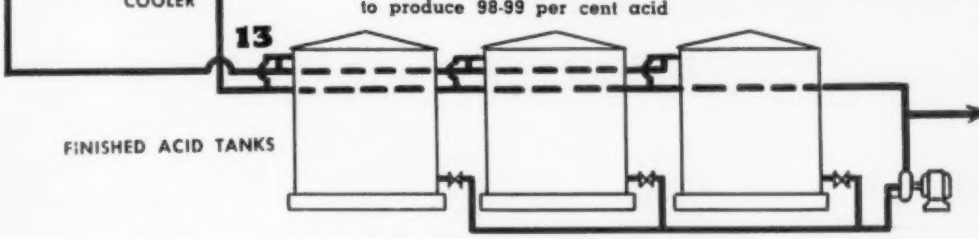




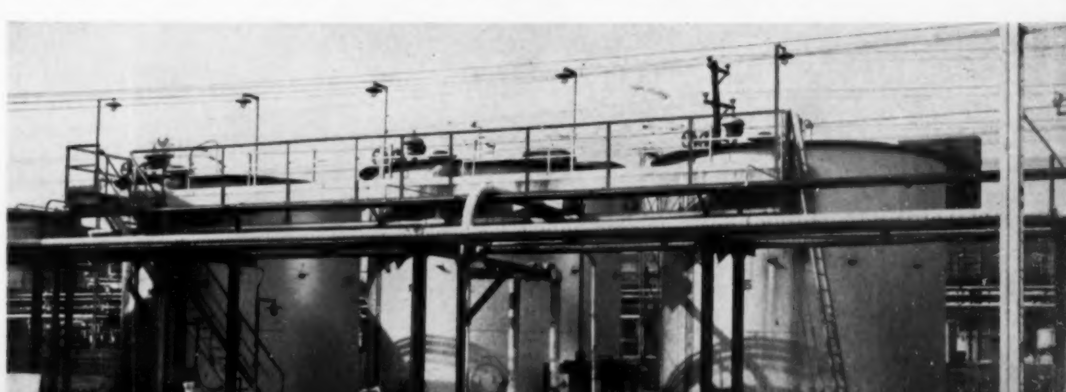
12 Acid circulating over center tower absorbs part of SO_3 to produce oleum. Tower on left absorbs remainder of SO_3 to produce 98-99 per cent acid

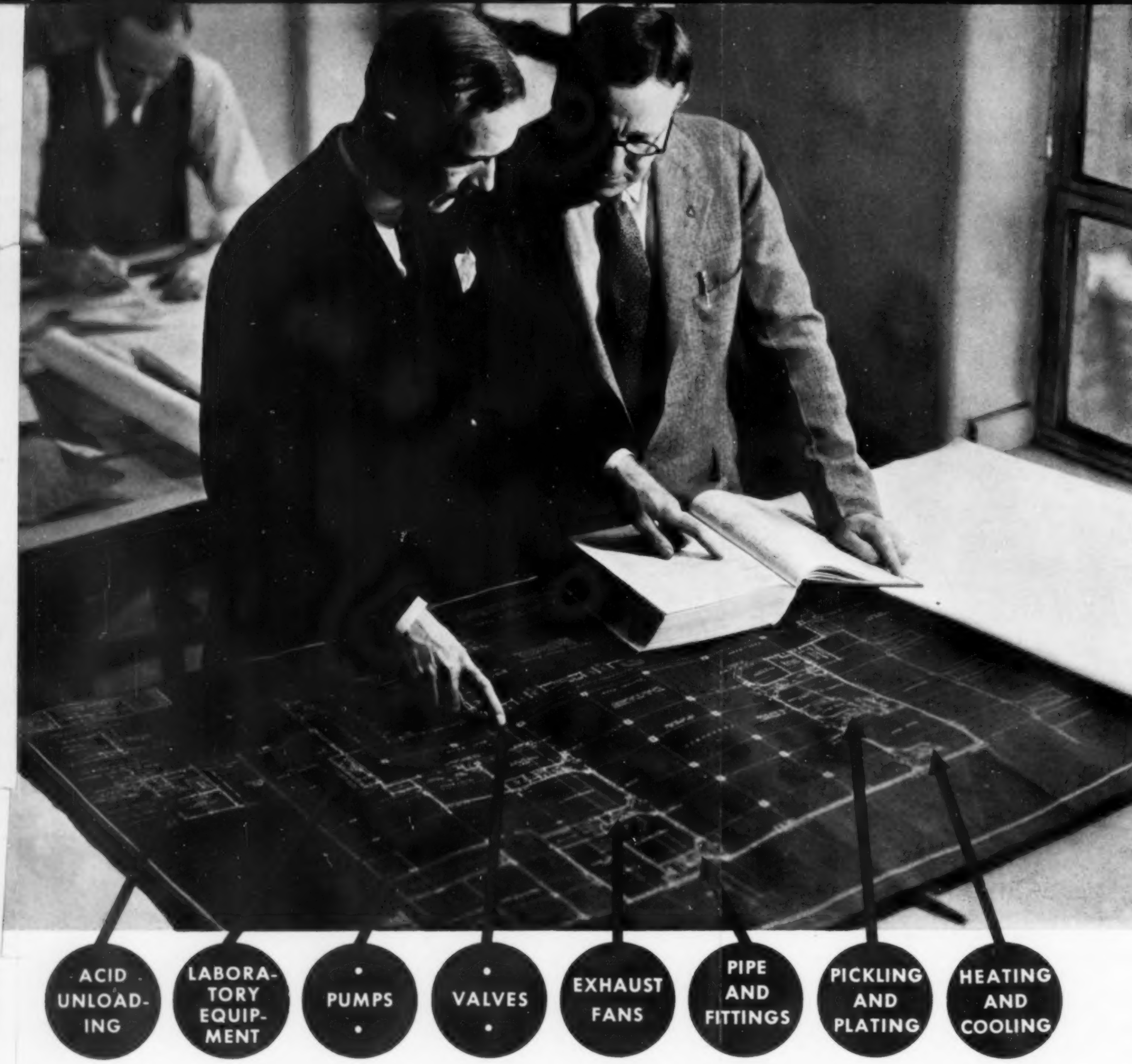
t exchangers where the SO_2 gas entering the con- heated by the SO_3 gas leaving the converters





13 Acid storage tanks where product acid is stored preliminary to use in the refinery. The recovered acid is of high quality and may be produced at any desired strength





POINTS WHERE CORROSION WILL OCCUR

Don't Overlook Them Now!

You are building a mightier America. Plan also to build *securely* for a future that will demand lower costs of production. Provide *today* for low maintenance costs *tomorrow*.

In *Duriron* and *Durichlor* (high silicon irons) and *Durimet* and other *Durco Stainless Steels* there is available to you a wide range of equipment for handling most economically corrosive liquids and gases.

Long after the blueprints are forgotten, Duriron Company equipment will be saving you needless expense for repairs and replacements due to destruction by corrosion. Send for special Bulletins on type of equipment needed.

DURIRON · DURICHLOR
CORROSION-RESISTING
DURCO
ALLOYS & EQUIPMENT

THE DURIRON CO., INC. DAYTON, OHIO

WELDED PIPE JOINTS MADE QUICK and EASY

...with Crane Socket Welding Fittings

SPECIALLY designed for welding—not made from screwed fitting blanks—of Crane high weldability forged steel. Extra deep sockets align and support pipe. No tack welding necessary. No icicles get inside of pipe. Properly proportioned band allows even heat penetration necessary for strong, clean weld. Recommended for processing fluids non-corrosive to iron and steel, for noxious gases, hard-to-hold liquids, and all high and low pressure water, oil and air lines.

... One of 38,000 Crane piping products designed to give improved service in specific needs. Available through Crane Branches and Wholesalers in all industrial centers.

Deep sockets save time—provide liberal come-and-go. Fittings are strong and rugged, yet light and compact—only slightly larger than the pipe.

Fittings have same inside diameter as pipe. Pockets are eliminated, and smooth, free flow assured when pipe is butted against socket shoulder.

CRANE

VALVES • FITTINGS
PIPE • PLUMBING
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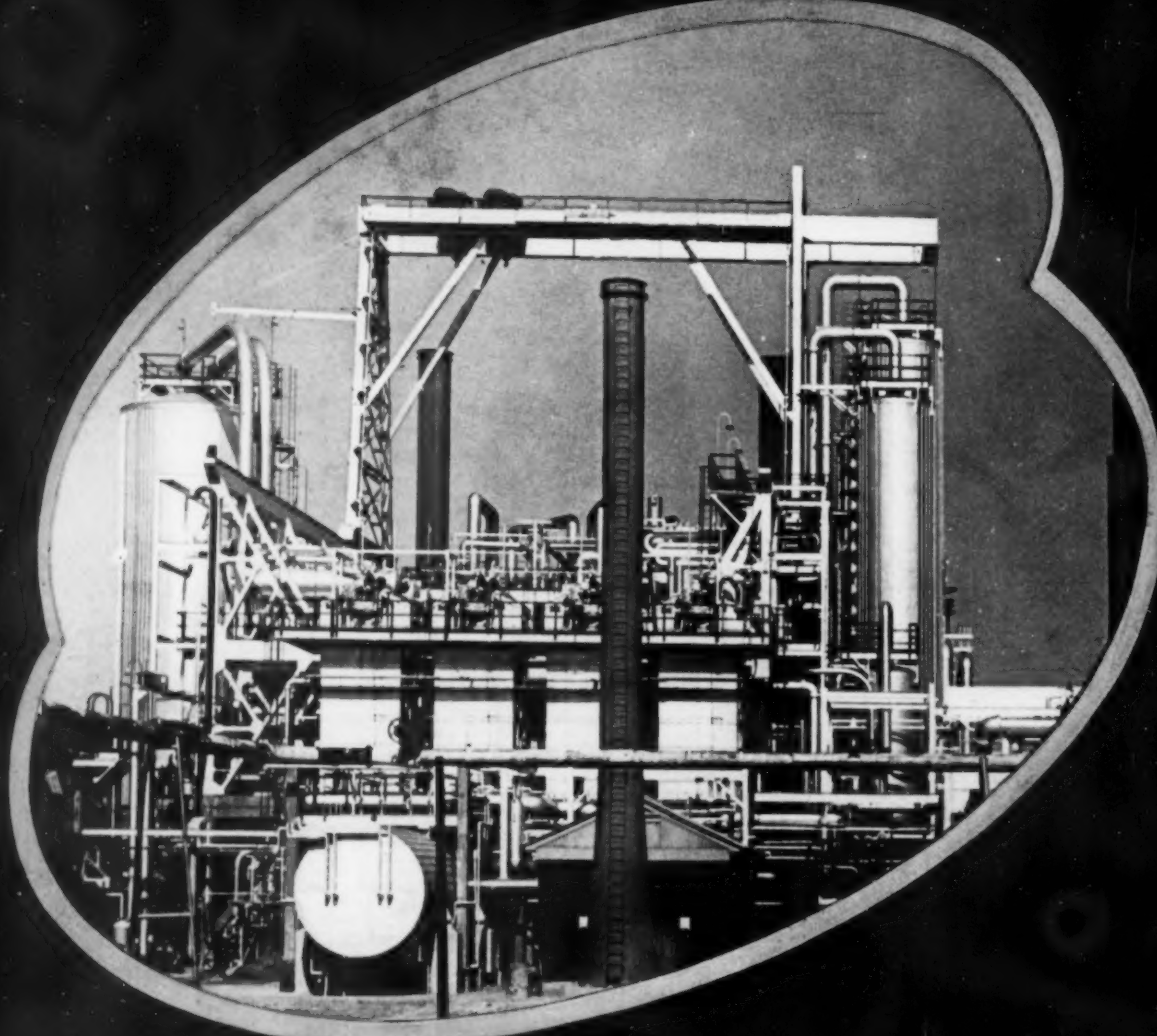
CRANE CO., GENERAL OFFICES: 836 S. MICHIGAN AVE., CHICAGO



Technical, Industrial, Personal

PLASTIC MANUFACTURERS FORM NEW ASSOCIATION

Representatives of fifteen large manufacturers of plastics met in New York last month and formed an association aimed at "offering cooperation in utilizing plastics for defense purposes." The group will be known as the Plastics Materials Manufacturers' Association, and includes a large share of the companies producing plastics in this country. Arnold E. Pitcher, general manager of the Plastics Department of E. I. duPont deNemours & Co., was named president; L. M. Rossi, vice-president of the Bakelite Corp., was elected vice-president, and John E. Walker, of Washington, D. C., was elected secretary and treasurer.

Mr. Pitcher described the organization as a movement to coordinate the resources of the member firms in a common effort. "As a result of the constantly increasing use of plastics for defense purposes and the necessity of working out suitable substitutes for some essential metals of which there is now a shortage, the plastics materials manufacturers felt it was important for the industry to be organized on a basis where better and more complete cooperation could be extended to the Army and Navy Munitions Board in utilizing plactics," he said.

The new organization is an outgrowth of the Cellulose Plastics Manufacturers' Association, which included only those firms making plastics based on cellulose. This group was formed in 1919. The new Association includes those concerns whose materials are based on urea, phenol derivatives, vinyl resins, casein, acrylics, cellulose, and styrene.

A Committee on Defense and Government Relations was formed, the duties of which are to act as a contact between the Association and the Army and Navy Munitions Board, or any other government agency interested in the organization's activities. L. M. Rossi was named chairman, with J. C. Brooks, of Monsanto Chemical Co., and E. C. B. Kirsopp, of Rohm and Hass Co., Philadelphia, as members. Mr. Pitcher and Mr. Walker serve in ex-officio capacities.

EXTENSIVE TECHNICAL PROGRAM FOR A.S.T.M. MEETING

Some 17 separate technical sessions are being scheduled for the Forty-fourth Annual Meeting of the American Society for Testing Materials to be held at The Palmer House, Chicago, during the week beginning June 23 and extending through Friday, June 27. This number of sessions is necessary for the presentation of the 100 technical papers and reports and to provide time for discussion.

The Sixth Exhibit of Testing Apparatus and Related Equipment will be in progress; the Society sponsors these exhibits every two years, at its annual meetings. There is also being sponsored the Fourth A.S.T.M. Photographic Exhibit on the general theme "Materials, Testing and Research."

Separate sessions of the meeting will be devoted to such topics as iron, ferroalloys; water, which includes a Symposium on Problems and Practice in Determining Steam Purity by Conductivity Methods; non-ferrous metals (two sessions); cementitious and building materials; steel, effect of temperature; fatigue of metals, corrosion; plastics; and concrete and concrete aggregates. Also being developed is a joint session with the Western Society of Engineers dealing with three topics of specific local interest, namely, water supply, sewage disposal, and sanitary conditions; and may involve some discussion of materials and problems in connection with the Chicago subway.

MONSANTO OFFICIALLY OPENS NEW PLASTICS PLANT

What is said to be the largest single plant in the United States for the production of various plastic raw materials was officially opened in Springfield, Mass. on April 29. John C. Brooks, vice-president in charge of the plastics division, Monsanto Chemical Co., and Roger L. Putnam, mayor of Springfield, and president of the Packaging Machinery Co., officiated at the brief dedication ceremonies that took place in the presence of approximately 50 visitors and company officials.

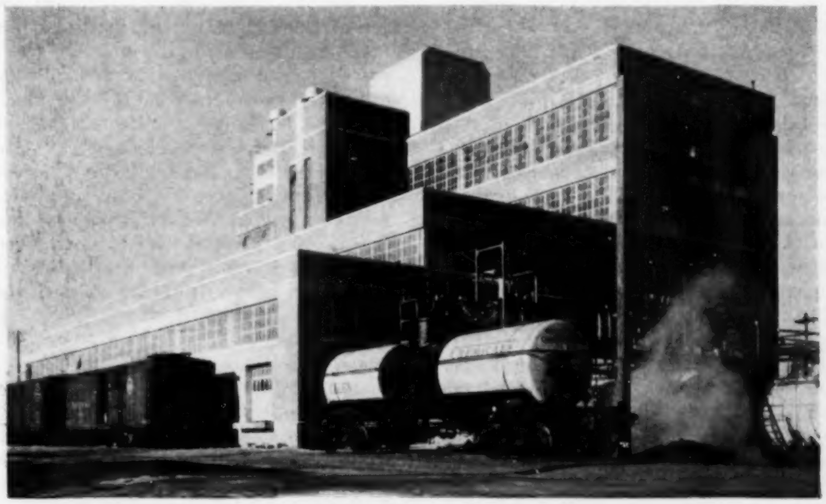
This newest Monsanto unit is for the manufacture of Resinox, phenolformaldehyde molding material now being widely used to replace strategic metals needed in the defense program. The new Resinox structure is the largest in the Springfield group and has a floor space of 55,000 square feet. It is thoroughly modern in every respect. Each floor is encircled completely with wide bands of windows which, aided by the setback type of construction, provides abundant natural light. An efficient ventilating and dust-collection system gives a clear, cool atmosphere in rooms that are normally hot and dusty. Construction is of steel-reinforced concrete with brick on the outside and tile within.

Although officially dedicated April 29, the Resinox plant has already been operating at or near capacity for the past four months. Furthermore, a sizeable addition is now planned to increase output by at least 50 percent—bringing capacity of 12,500,000 lb. to approximately 19,000,000 lb. of molding compound.

BARRETT WILL EXPAND PHTHALIC ANHYDRIDE PRODUCTION

In view of the fact that supplies of phthalic anhydride have been very limited for some time, considerable importance is attached to the announcement that The Barrett Co., a subsidiary of Allied Chemical & Dye Corp., has acquired additional land adjacent to its Frankford, Philadelphia, plant. A new plant will be erected for the expansion of the company's coal-tar chemical business and its present facilities for the production of phthalic anhydride will be more than doubled.

New Resinox plant of Monsanto Chemical Co. at Springfield, Mass. officially dedicated on April 29



News from Washington

WASHINGTON NEWS BUREAU, McGRAW-HILL PUBLISHING CO.

MORE complete control has been organized for allocation and distribution of commodities for which adequate supplies are not available to serve both defense needs and civilian desires. Cooperation of the priorities and price fixing groups has been perfected. Further legislation to make legal and binding many arrangments that hitherto have been "voluntary" is being perfected by Congress during the early part of May.

Many metals are already under close control if not actual priority allocation. Before long it is expected that practically all metals will be so watched and managed. No chemicals had come under such formal control at the first of May, but the shortage of ammonia lead to recurring rumors during April that this commodity would be the first one which would require official regulation.

Metal Rulings

The chemical process industries are most concerned with metals because they are the users. But the chemical manufacturer can get an accurate forecast of probable chemical control by review of present metal rulings. There is every reason to believe that analogous policies for chemicals will be fixed more or less definitely as time goes on and tight situations develop. Perhaps only a few chemicals will ever need complete or intimate control. But many voluntary arrangements are going to be necessary as the tempo of defense manufacture is stepped up. Here are some of the metal actions that foreshadow chemical policy.

Nickel distribution was not only controlled, but nickel stocks were actually inventoried by the Bureau of Mines to make sure that some of the more aggressive buyers were not too acquisitive for the good of all. That action of late March and early April clearly indicates how distribution control is going to be practiced under the new general orders of O.P.M. officially published on May 2.

Conservation methods are best illustrated by the activities with respect to tin. Complete substitution of other metals has been urged. And curtailment of the quantity used for some purposes, where complete substitution has not been possible, is being encouraged. For example, the paint industry has shifted from tin-plate to terne-plate containers, saving at least 50 percent of the tin requirement for that industry. Food canners have promised a saving of approximately 17 percent by using less weight of tin per unit of can surface. And the reclaiming of tin from used containers has been studied.

A system of allocation has been developed with aluminum as the first metal controlled so that civilian users as well as defense products users would receive fair treatment. The defense users get class A priority which means that they get all the aluminum they need but in a time sequence according to whether they are A1, A2, or some lower class recipient. The civilian users get B class preferences ranging from B2 for the most urgent to B8 for the least important purposes. In this B-preference group the primary aluminum allocated is based on a percentage of the 1940 use, being from 80 percent to 10 percent as one descends the scale from B2 to B8 priority. These same groups can get a larger percentage of their 1940 use if they can employ a low-grade or secondary metal. The allocations of this class are from 100 percent down to 50 percent of the 1940 poundages. To aid in administering all this priority there has been prepared an elaborate dictionary of aluminum uses giving clearly the classification assigned.

The whole copper, lead, zinc, and related metals situation is being worked out on virtually a rigid priority scheme. But most of the rulings so far remain voluntary. The real troubles for copper and zinc lie ahead. The big demand for them will come when active ammunition manufacture puts a peak in the demand for brass for cartridge cases.

Substitution of one metal for another is being pressed vigorously, especially in the ferro alloy field. Many users of tungsten are being urged to prepare to use molybdenum for their alloy steel requirements. This is "an effort to be prepared should there be any curtailment of imports of tungsten".

Price Controls

The establishment under Administrator Leon Henderson of the new Office of Price Administration and Civilian Supply (OPACS) centralizes two types of controls. Henderson continues the job of keeping industrial prices in line and acquires also consumers' goods price control along with a new subordinate, Dean Harriet Elliott, formerly the consumers' price watcher of the old Defense Commission. Also Henderson is to have a large share of the authority over civilian supply of goods on which class B priorities are fixed. The division of authority between Henderson and Stettinius on this point was still being argued the first part of May.

Henderson's first attack on most price situations continues to be by sharp warnings. During recent weeks he has issued critical comment on prices for cadmium, quicksilver, lead, copper, brass, and a variety of other metals and industrial commodities. In some cases the warnings have indicated the prices which OPACS believes to be reasonable. In other cases generalizations regarding price trend or price factors have served.

Important legislation was on its way through Congress early in May. If enacted as proposed there will be full and unquestioned authority for price fixing and for the regulation of priorities on goods not directly involved in defense orders. The old legislation was adequate for controls on the defense orders themselves; but many thought that controls had to be altogether voluntary when they reached the B class of priorities. That will be remedied and the whole program will be supported with ample authority when the pending act is finally approved.

Distribution Controls

General metals order No. 1, issued May 2 by Stettinius, gives a clear indication of one administrative plan. It provides that for certain materials a supplier will not ship to customers unless the customers have first indicated their stock on hand, their future requirements, and other available supplies. Thus, excess inventories are to be prevented and a complete distribution control established for: antimony, cadmium, chromium, cobalt, copper, ferro-alloys of all types, iridium, iron and steel products, lead, manganese or speigeleisen, mercury, molybdenum, nonferrous alloys of all types, tin, vanadium, and secondary metals of scrap containing these. A parallel type of chemical control is to be expected later if serious shortages develop.

In planning for the longer range effect on prices, Henderson is urging plant expansion. The immediate purpose is to insure adequate supply for defense and civilian uses. A secondary purpose is to be sure that the prices do not rise during the emergency period. And third, not negligible in Henderson's personal thinking, is the hope that post-emergency supplies will be so abundant from enlarged plant facilities as to insure sharp price declines. That effect is desired by the New Deal economists as a part of their effort to insure larger consumption of materials because the unit cost will be lower.

Reclaiming of Tin

A committee of chemists and engineers working under the auspices of National Academy of Sciences reported in mid-April on tin recovering methods. These recommendations to O.P.M. were handled by the Unit of Conservation under the direction of Robert E. McConnell. He promptly released the findings without forecast as to either whether or when official action would be taken.

The committee concluded that not more than 12,000 long tons of tin could be recovered annually by gathering of used tin cans in certain urban areas of the United States. They estimated

that approximately 26,000 long tons would theoretically be available for recovery, but expressed the belief that the smaller quantity is all that could practically be reclaimed as secondary metal under existing methods for detinning.

Initial operation, if and when started, will be centered around the cities where detinning plants now exist—New York, Pittsburgh, Chicago, and San Francisco. No new methods of de-tinning were investigated which gave any promise of advantage over standard recovery by a solution of tin in an alkaline bath containing an oxidizing agent. After removal of the lead simultaneously dissolved, the resulting sodium stannite would be electrolyzed with recovery of high-grade tin by well-established commercial techniques.

The committee definitely recommended "(1) That the Government of the United States does not spend public funds for the erection of new detinning plants for the recovery of tin from used tinned containers unless and until an emergency in the supply of tin renders it imperative to conserve tin without regard to its cost.

"(2) That the Government of the United States, immediately upon the finding of such an emergency, enter into negotiations with the municipal authorities of the larger urban areas to the end that suitable methods of collection can, by such cooperation, be instituted, it being understood that the necessity requires it as a defense measure without regard to cost.

"(3) If and when the Government of the United States finds it imperative to so conserve tin, that it immediately ask the detinning industries abovementioned to submit proposals for the use of existing facilities in their several plants in the four large metropolitan areas."

Trust Busting

Thurman Arnold's trust-busting activities in the "war industries" field are heading for large-scale expansion. The House of Representatives has passed, with Senate concurrence considered likely, an appropriation of $2,325,000 for this division for the fiscal year beginning July 1. This amount is the largest in the history of trust-busting, nearly double the current year's funds, $750,000 more than the President requested, and $25,000 more than even Mr. Arnold asked for in his own estimate of needs to the Budget Bureau.

Congressional liberality came after Mr. Arnold testified before the House appropriations sub-committee, giving promise of great things to come if only sufficient funds were available. Particularly, Mr. Arnold emphasized, the Division intends to concentrate on activities in war industries—more cases with the alleged German tieup angle exemplified by the recent examples in aluminum, magnesium, and lenses. Specifically singled out for mention in the hearings as avenues in for investigation were zinc (now underway), iridium, tungsten carbide, dyes, and manganese.

Mr. Arnold summed up the policy of his division in these words to the committee: "We are doing two important things which the emergency forced on us. The first was to see that the Government does not pay through the nose for war materials; and, second, to see that the prices of the necessities of life do not soar."

Chemical Miscellany

New C.W.S. Chief—A successor to Major General Walter S. Baker as Chief of Chemical Warfare Service has been expected since announcement of his retirement on April 30. Unless some other officer of the rank of general is available for this assignment, the new nominee will have to be confirmed by the Senate when named.

Commerce Bureau Shifts — The old chemical division of the Bureau of Foreign and Domestic Commerce is no more. It and all of the other commodity divisions were abolished, effective April 7, by administrative order of Director Carroll L. Wilson. C. C. Concannon is now one of the industrial consultants, a designation given to the deposed division chiefs. Temporarily, T. W. Delahanty is serving as the chief of the export-import market-information Unit; later he becomes chief of the durable materials unit in the industrial economy division. The balance of the chemical division staff are scattered in the various parts of the reorganized Bureau.

Paint Problems—The paint industry is cooperating actively with Defense officials and with Department of Agriculture specialists in its effort to get more nearly adequate drying oil supplies. Drastic means for stimulating drying oil substitutes for unavailable imported oils may be necessary. Soap makers are almost equally worried about shortages of oils required for high-grade soap-making. Chemical engineers as well as agricultural specialists are collaborating with the paint men. Shortage of lead and zinc pigments is also a worry, but one which is a little farther in the future than the oil troubles. Oil shortage may become serious by late 1941; it is sure to be of grave concern during next calendar year.

Sugar Shortage?— Shortage of ship space may compel Britain to use West Indies sugar sources instead of normal Far East supplies. The haul is less than half as long, especially with the Mediterranean closed. This may produce shortages of sugar in the United States. But the Department of Agriculture in making its 1941 allocations refused to take account of this prospect. It even declined to give requested consideration to the difficulty of moving Philippine sugar into the United States.

More Coke Capacity — Continuous operation of blast furnaces at close to 100 percent capacity is exhausting all normal supplies of furnace coke. Several new plants or extensions of plants making byproduct coke have been announced. Government officials are also cooperating with the industry on the resuscitation of the beehive coke plants, many of which have been idle for many years. Rebuilding of these is a short-time task, requires little or no steel, and ensures quick delivery of acceptable foundry and furnace coke. The industry welcomes this activity as an aid to quick fuel supply. It also is recognized that it prevents loading down some units of industry with needlessly large post-Emergency capacity in expensive byproduct coke plants.

Enough Bauxite! — A survey of the Bureau of Mines reported late in April discloses that enough domestic bauxite can be produced to serve the aluminum industry for some time even if lack of shipping from Latin America should cut off normal supplies of this raw material. In two months domestic bauxite output could be multiplied threefold; in four months, fivefold, with little new equipment. Much of the increase would be obtained by three-shift, seven-day operation of existing mining establishments. The Bureau does not recommend this, but points out the element of comfort contributed by this knowledge at a time when ship space is at such serious premium.

Synthetic Rubber—Up to the first of May the government had not yet announced any support for the many synthetic rubber programs which have been proposed to it in industry conferences. The whole matter appears to be in an R.F.C. pigeonhole with the industry unable to make even normal new progress because of the threat of potential government competition in huge R.F.C. plants. Although these are only at the talk stage, they discourage the industry in its development program significantly, Washington is beginning to discover.

More Magnesium — No official announcement had been made, but it was well known in Washington, that the magnesium requirements of Uncle Sam are going to be of the order of 200 million pounds per year. This is more than double the highest official estimate which has ever been admitted. The increased requirement is partly for substitution of magnesium alloys for aluminum alloys. But not a negligible part of the new demand is for incendiary raw material.

Priority Handbook—A full disclosure of the priority policy as of April was published by O.P.M. in a handbook on the operation of the priorities system titled "Priorities and Defense". It published also the priorities critical list as of March 15, 1941. Promised in future editions or by suitable releases are the amendments made from time to time in this list. Such new list is expected monthly, about the 15th of each month. The book also includes the necessary instructions and sample forms showing how both processors and users can manage priority business.

TRANSPORTATION OF DANGEROUS ARTICLES SLIGHTLY BROADENED

Container rules for transportation of combustibles, oxidizing chemicals and other "dangerous articles" have been slightly broadened by an Interstate Commerce Commission order effective July 1. Principal changes relate to drums. A single-trip five-gallon drum has been O.K.'d for chromic acid. This is the first case in which any single-trip container has been permitted for transportation of a corrosive liquid.

Permission has also been granted for use of 5B metal barrels or drums in the transportation of inflammable liquids. This is a 16-gauge returnable drum, lighter in weight than any heretofore permissible for these combustibles. Use of the 18-gauge single-trip metal drums (Spec. 17X and 17E), for foreign shipment only, represents another new departure. This is by far the lightest weight drum ever authorized for such duty. One unofficial comment described this practice as "potentially rather risky."

Transportation of amorphous red phosphorous has also been modified slightly. Single-trip bare metal barrels or drums may now be used if the gross weight does not exceed 160 pounds. Outside wooden boxes are not required around these metal containers.

ALLIED CHEMICAL & DYE CORP. ESTABLISHES FELLOWSHIPS

Graduate fellowships have been established by Allied Chemical & Dye Corp. for the academic year 1941-42 to encourage advanced training in chemistry and chemical engineering. Recipients, selected by the universities, will be outstanding graduate students with demonstrated aptitude for research. Subjects, also chosen by the universities, are not restricted to those connected with the products or interests of Allied's subsidiaries. Stipend of each fellowship is $750.

The universities and colleges to which awards have been made are: University of California, California Institute of Technology, Columbia University, Cornell University, Harvard University, University of Illinois, Massachusetts Institute of Technology, University of Michigan, University of Minnesota, Northwestern University, Ohio State University, University of Pennsylvania, Pennsylvania State College, Princeton University, University of Wisconsin, Yale University.

NEW STANDARDS SET UP FOR USE OF TOXIC SUBSTANCES

The American Standards Association which has been working to establish safe limits for toxic substances used or given off as a part of common industrial processes has announced new safety standards for the use of four toxic materials. The new standards provide for carbon monoxide that the maximum allowable concentration shall be 100 parts per 1,000,000 parts of air by volume with atmospheric oxygen not below 19 percent by volume adjusted to 250 and 760 mm pressure for exposures not exceeding a total of eight hours daily, and 400 parts per 1,000,000 parts of air by volume for exposure not exceeding one hour daily. For hydrogen sulphide the maximum allowable concentration is 20 parts per 1,000,000 of air for exposures not exceeding eight hours daily. For carbon disulphide, it is recommended that the concentration be kept below 20 parts per 1,000,000 parts of air for general factory purposes and for benzene or benzol 100 parts per 1,000,000 parts of air for exposures not exceeding eight hours daily.

W. S. LANDIS ELECTED PRESIDENT OF CHEMISTS' CLUB

At its annual meeting held on May 7, The Chemists' Club of New York elected as its twenty-eighth president, Walter S. Landis, vice-president of the American Cyanamid Co. Other officers elected were: Robert L. Murray, Hooker Electrochemical Co., nonresident vice-president; Per K. Frolich, Standard Oil Development Co., suburban vice-president; Charles R. Downs, Weiss & Downs, and Albert B. Newman, College of the City of New York, trustees for three years. Reelected were Ralph E. Dorland, Dow Chemical Co., resident vice-president; Ira Vandewater, R. W. Greef & Co., treasurer; and Robert T. Baldwin, secretary.

DuPONT WILL BUILD NEOPRENE PLANT AT LOUISVILLE

On May 7, W. S. Carpenter, president, announced that E. I. duPont de Nemours & Co. will build a new plant for the manufacture of neoprene at Louisville, Ky. The plant will be built, financed, and operated by the company and construction will start at once. The capacity of the plant will be 10,000 tons a year which exceeds the present total combined production of all synthetic rubbers, including the 6,000 tons made in the duPont plant at Deepwater, N. J. These totals refer to long tons and before the end of the year the capacity of the Deepwater plant will be increased to 9,000 tons.

NEW CHEMICAL ENGINEERING BUILDING FOR M.I.T.

Immediate construction of a large new laboratory to house the department of chemical engineering of the Massachusetts Institute of Technology was announced last month by Dr. Karl T. Compton, president of the Institute. Dr. Compton said expansion of facilities for the department has long been an urgent need and the executive committee has authorized the project because of increasing opportunities for the Institute to use its facilities for research and for training programs relating to the national defense. The new chemical engineering building will be located behind and adjacent to the the main educational building east of the central dome.

PORCELAIN ENAMEL INSTITUTE HOLDS ANNUAL MEETING

The Tenth Annual Meeting of the Porcelain Enamel Institute was held at French Lick, Ind., April 17-18. Forty-seven executives of various plants were present including not only representatives of the enamelling industry but also the supplying manufacturers. In addition to the presentation of technical papers, the annual business session was held and officers for the coming year were elected as follows: P. B. McBride, Porcelain Metals Corp., Louisville, reelected president; R. H. Turk, The Porcelain Enamel and Mfg. Co., Baltimore, vice-president; R. R. Danielson, Metal and Thermit Corp., Carteret, N. J., reelected vice-president; William Hogenson, Chicago Vitreous Enamel Products Co., reelected treasurer; and C. S. Pearce continued as managing director.

CONTRACT FOR ELECTRIC PLANT AT WEST HENDERSON

Shortly after the middle of last month, the War Department announced a supplemental contract, approved by the Office of Production Management, with the Atmospheric Nitrogen Corp., New York, for the construction of an electric generating plant at an estimated cost of $1,100,001 at the Ohio River Ordnance Plant, West Henderson, Ky.

COLUMBIA RECEIVES PORTRAIT OF DR. M. T. BOGERT

A portrait by Irving Wiles of Dr. Marston Taylor Bogert, professor emeritus of organic chemistry in residence at Columbia University was presented to the University by Ph.D. graduates of Dr. Bogert at a dinner held at the Chemists' Club, New York, on the evening of May 2. Dr. Bogert was the guest of honor and Frederic R. Coudert, University Trustee, accepted the painting on behalf of Columbia where Dr. Bogert has been a member of the teaching staff for 47 years.

FEDERAL GRANTS FOR CHEMICAL ENGINEERING COURSES

Federal grants of funds for expansion of facilities and acquisition of equipment for chemical engineering courses at any American college is provided in legislation before Congress, practically certain to pass. A limit of $1,000,000 is set on grants for any single institution. Grants will be made by the Federal Security Administrator, acting through the Office of Education.

Problem Solvers . . .

when foreign sources of supply are cut off

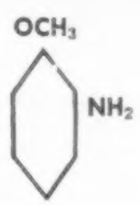
To the right are fourteen available amines that are finding important uses in the manufacture of dye-stuffs. Perhaps one of them can be of assistance in the solution of *your* problems.

Two of the most important of the group are the anisidines, Monsanto specifications for which are shown below. Both the ortho and para anisidines are used as components of various azo dyes, the ortho compound imparting an unusual brightness of shade which is probably due to the position of the methoxy group in the molecular structure.

The amines, however, represent only a few of the Monsanto Intermediates available to American Industry. For a complete list, full descriptions, and technical advice on your particular problems, inquire: MONSANTO CHEMICAL COMPANY, St. Louis, U. S. A.

AVAILABLE AMINES

o-Aminodiphenyl, Tech.
p-Aminodiphenyl, Tech.
o-Anisidine
p-Anisidine
o-Chloraniline
m-Chloraniline
p-Chloraniline
2:5 Dichloraniline
Cyclohexylamine
Dicyclohexylamine
o-Nitraniline
2:4 Dinitraniline
o-Phenetidin
p-Phenetidin



Mol. Wt.
$C_6H_4 \cdot OCH_3 \cdot NH_2 = 123.08$

ORTHOANISIDINE

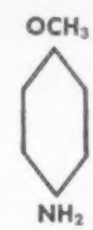
MONSANTO SPECIFICATIONS

Appearance: Reddish brown to amber liquid.

Crystallizing Point: 5.3°C. minimum.

Solubility in HCl: Complete.

Distillation Range: 223.0° to 226.0°C. (95% within 1.2°C.)



Mol. Wt.
$C_6H_4 \cdot OCH_3 \cdot NH_2 = 123.08$

PARA ANISIDINE

MONSANTO SPECIFICATIONS

Appearance: Brownish crystalline mass —subject to darkening on aging.

Crystallizing Point: 57.2°C. minimum.

Distillation Range: 240.0° to 243.0°C. (95% within 2°C.).

MONSANTO CHEMICALS
SERVING INDUSTRY...WHICH SERVES MANKIND

GOVERNMENT COMPANY IN GERMANY TO REGULATE OIL INDUSTRY IN CONQUERED COUNTRIES

Special Correspondence

FURTHER Reich control of continental raw materials was indicated last month in the formation of the Kontinentale Oel Aktiengesellschaft. The new government-controlled oil company, capitalized at 80 million RM and headed by Dr. Funk, Minister of Economics, is modeled after the Hermann Goering Steel Works and is planning to participate in production and distribution of oil from concerns in Reich-controlled territory. Fifty million RM have been subscribed by leading German oil producers, including I. G. Farben, Gelsenkirchen, and Wintershall, and shares for the remaining 30 million RM are being offered to the public. The formation of the new enterprise indicates the Reich's preoccupation with its present oil problem as well as with post-war reconstruction.

A similar participation occurred during the world war, especially in Rumanian oil companies, chief continental European producers outside of Russia. After the war, British and American firms supplanted German interests in this area. Rumanian production has declined recently, however, from 8.7 million metric tons in 1936 to an estimated 6.1 million tons in 1940. In addition to controlling the Rumanian supply, Nazis have also largely taken over the output of less important wells in southern Poland, Austria, and Hungary. It can be assumed that the larger part of central and eastern European oil output has been requisitioned by the Reich to augment supplies seized in France and the Low Countries.

In 1939 when the war broke out and the Reich was suddenly cut off from its main sources of oil, it was producing only about two million tons a year, and synthetic production accounted probably for another two million tons. In the meantime, it is estimated that German synthetic gasoline production reached three million tons. The Soviets are believed to have supplied the Reich with more than a million tons of oil in the first 12 months following the first trade agreement of August 1939, and this amount was boosted by 50 percent in the second agreement.

The recent Nazi drive in the Balkans if continued to the Suez would put the Reich close to Iraq and Iran, where the Near Eastern oil output totals 17.5 million tons a year. Control of this supply would make the Reich virtually blockade proof and would greatly increase the problem of Britain's own oil supply.

The setting up of a pro-German government in Iraq after the recent rebellion indicates Nazi political and economic interest in this area. Iran (Persia), whose oil production reached 78 million barrels in 1940, traded with Germany, Japan, United States, and the United Kingdom, in the order named. Iran imports of industrial equipment and automobiles from Germany expanded considerably during the past year under the new Iran-German trade agreement. Normally the Soviet Union is the most important trade partner of Iran and may become so again since trade was resumed recently, but for the year 1939-1940 Germany was by far the leading trade partner.

With the conquest of Yugoslavia, which got 51 percent of its imports from Germany in the first nine months of 1940, the Reich has gained virtually complete control of the trade of the Balkans. The Croatian and Slovenian areas in the north, which were separated from the Serb areas in the south and east, are the chief agricultural areas of Yugoslavia, while the Bor copper deposits, largest in Europe and recently purchased by German interests from French owners, are located in east Serbia. Chief bauxite deposits are in Dalmatia on the west coast along the Adriatic. To facilitate bauxite imports the Reich recently lifted all import duties on both crude and prepared bauxite.

Chemicals amounted to 12 percent of Yugoslavia's total import trade in 1939. Chief suppliers were Germany, Italy, and England, in the order named, and products imported were rayons, coal-tar dyes, heavy chemicals, rubber goods, and pharmaceuticals. From Yugoslavia the Reich imported some heavy chemicals, tanning materials, and fertilizers.

Hungary, which imports one-fourth of the chemicals it consumes—since coal-tar dyes and rayon are entirely imported—but has a modest chemical industry of its own, manufacturing heavy chemicals, soaps, pharmaceuticals, fertilizers, and ferro-alloys, is increasing its exports of medicinals. During the past year near Debrecen the area planted in poppies for narcotics has been enlarged considerably. It is claimed the Hungarian poppies contain a third more morphine than those raised in Yugoslavia, Turkey, or Macedonia. The Reich imports, chiefly from Hungary, a large part of its tea requirements in the form of peppermint leaves, which are being used to brew a fairly satisfactory substitute tea.

It is reported by the Tobacco Research Institute in Forchheim, southern Germany, that edible oil can be extracted from tobacco seeds. From two and a half acres of plants, they claim more than 2,000 pounds of seed with a yield of nearly nine gallons of oil can be obtained. At the beginning of this year the first table rapeseed fat was marketed on a large scale in the Reich, and rapeseed planting has been expanded so that it will probably reach 500,000 acres by the end of 1941. In Denmark, too, for food and fodder purposes, it is planned to plant 750,000 acres in oil bearing seeds in addition to 150,000 acres in flax and hemp.

In the paint field, I. G. Farben has recently announced the development of a new synthetic product "Appretan" to serve as a substitute for imported shellac. For spraying paint, a new gun was exhibited for the first time at the Vienna spring fair. It calls for nebulizing the fluid by pressure applied directly to the liquid instead of by the usual indirect atomizer principle. It is claimed that with the new gun a more economical use of enamel and an evener coat of paint is possible in application.

Because light colored buildings are easier targets in night air raids, a recent air ministry decree requires that for the duration of the war in new building, repairs, alterations, or house and industrial expansions, the outer and upper surfaces of a building must be painted or plastered with a dark color. An industrial air raid precaution making blacking out of windows unnecessary is a luminescent paint for all vital apparatus, instruments, and parts of power houses, chemical plants, and water works. Developed by the Auergesellschaft A.G., the luminescent paint is activated by special lamps which send out hardly any visible rays and are independent of the regular light current.

The use of flashlights during blackouts has greatly increased the demand for dry cell batteries, production of which in the Reich exceeded 500 million units per year even before the outbreak of the war. During the war some manufacturers started replacing manganese ore (Braunstein) cells with activated carbon, and claim that although such cells have a slightly smaller initial output than manganese dry cells, they have a greater total output and a longer lifetime.

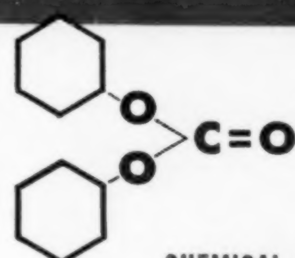
The State Railway and the Postal Service, two largest users of impregnating materials for preserving railway ties and telephone poles, are facing considerable difficulties, since tar, arsenic, and chrome compounds are no longer available as impregnating materials. In 1938, 120,000 tons of such tar oil and 2,000 tons of impregnating salts were used to treat 2 million cubic meters of wood with tar oil and .5 million cubic meters of wood with the salt compounds in solutions. Since these materials are felt to be more vitally needed elsewhere, older type impregnating materials are being used again, among them fluor-dinitro mixtures of the "Basilit" type and fluor-sodium-xylenolnatrium mixtures of the "Flunax" type. Since newly acquired Silesian zinc deposits have relieved shortages in this metal, old abandoned processes using zinc chloride impregnating materials are being revived.

GENERAL CHEMICAL COMPANY ANNOUNCES COMMERCIAL AVAILABILITY OF

diphenyl carbonate

(CARBONIC ACID, DIPHENYL ESTER)

STRUCTURAL FORMULA:



PHYSICAL PROPERTIES:

Appearance—white crystalline solid, white needles from alcohol.

Molecular Weight—214.

Melting Point—78° C.

Boiling Point—302° C.

Density—1.1215 87/4.

SOLUBILITIES:

Insoluble in water.

Quite soluble in acetone, hot alcohol, benzene, carbon tetrachloride, ether, glacial acetic acid, and many other organic solvents.

CHEMICAL PROPERTIES:

1. Can be halogenated and nitrated in characteristic manner.

2. Readily undergoes hydrolysis and ammonolysis when treated respectively with inorganic bases, ammonia and amines.

POSSIBLE INDUSTRIAL APPLICATIONS:

1. Diphenyl carbonate shows plasticizing properties and has been recommended as a plasticizing agent.

2. In the manufacture of other carbonates by substitution.

General Chemical Company is pleased to announce the availability in commercial quantities of the following chemicals:

XANTHONE • SALICYLAMIDE

DICRESYL CARBONATES

PHENOXY BENZOIC ACID

GENERAL CHEMICAL COMPANY

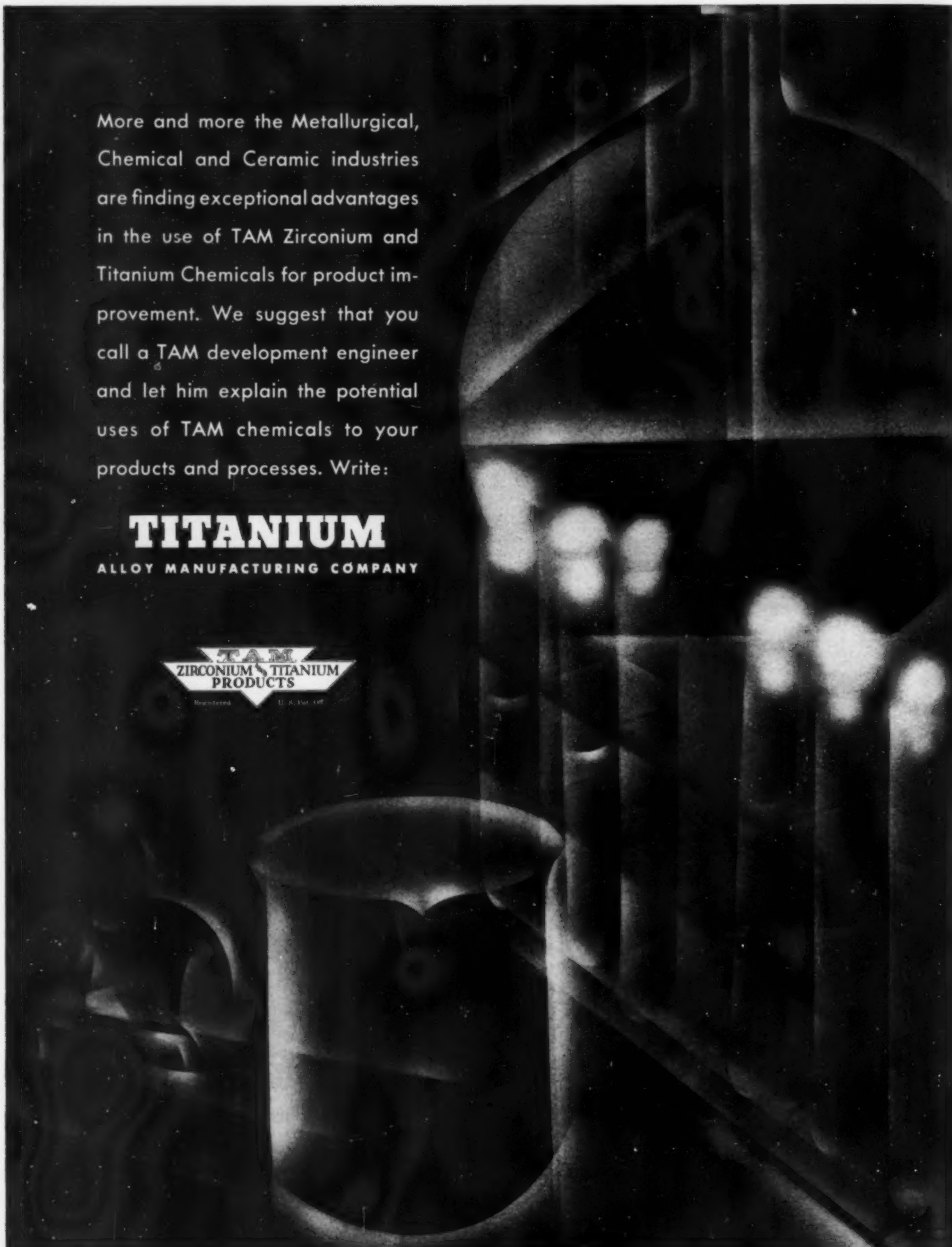
40 RECTOR STREET, NEW YORK, N. Y.

Sales Offices: Atlanta • Baltimore • Boston • Buffalo • Charlotte (N. C.) • Chicago Cleveland • Denver • Detroit • Houston • Kansas City • Milwaukee • Minneapolis Newark (N. J.) • New York • Philadelphia • Pittsburgh • Providence (R. I.) • St. Louis • Utica (N. Y.)

Pacific Coast Sales Offices: San Francisco • Los Angeles

Pacific Northwest Sales Offices: Wenatchee (Wash.) • Yakima (Wash.)

In Canada: The Nichols Chemical Company, Limited • Montreal • Toronto • Vancouver


More and more the Metallurgical, Chemical and Ceramic industries are finding exceptional advantages in the use of TAM Zirconium and Titanium Chemicals for product improvement. We suggest that you call a TAM development engineer and let him explain the potential uses of TAM chemicals to your products and processes. Write:
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NEWS OF PRODUCTS AND MATERIALS

CORROSION-RESISTANT LINING

A material for lining of process equipment to prevent corrosion has recently come out of the research laboratories of the United States Stoneware Co. Much like a jelly in appearance and consistency, Tygon may be formed into tough patent leather-like material for lining of equipment; into soft resilient compounds for sheeting, tubing and molding use; into liquids for spraying, dipping or painting surfaces subject to corrosive action.

PHENOLIC MOLDING COMPOUND

A new general-purpose phenolic molding compound made by Durez Plastics & Chemicals, Inc. is known as Durez 775. It was developed to make available a material which would have a wider range of application than existing materials. Among the improvements over present compounds of this type are listed: Lower water absorption, slightly higher flexural and tensile strength, heat resistance of 400 deg. F. It is also stated that Durez 775 Black has excellent molding characteristics, fast cure, and will deliver a smoother, more lustrous finish than the average general-purpose material.

WHITE PIGMENTS

A new group of paint pigments 33 percent more effective in hiding power and opacity than any known today has been announced by E. I. du Pont de Nemours & Co. These pigments are improvements on the titanium dioxide type which have come into wide use in the industry in recent years. The process involved was described as a transformation of the crystalline structure in the minute titanium dioxide particles comprising the pigment. By altering the form of the finely ground crystals it is possible to deflect more of the light rays striking the surface, resulting in a more opaque covering. The index of refraction, a property determining the opacity of a substance is substantially increased in each instance.

CLEANSING AGENTS

A new cleansing agent which is expected to double the life of certain metals has been introduced by J. B. Ford Co. Aluminum and light metal alloys are given greater protection against corrosion by bathing them in the solution. The new chemical was described as a refinement of detergent previously used for cleaning metals plus some new materials. It is explained that the detergent bath precedes the finishing process, removing lubricants used in metal fabrication and matter which might cause rust.

NEW PLATING METHOD

The potentialities of corronizing, an electrolytic method of plating, as a force in the national defense program for conserving vital metals, notably zinc, were outlined by the Standard Steel Spring Co. This method reduces plating metal requirements, notably zinc by as much as 90 percent without sacrificing corrosion resistance or durability, it has been stated.

INERT FOR PAINT INDUSTRY

A new inert material for the production of paint, rubber and other materials has been announced by Wishnick-Tumpeer, Inc. Witcarb is a finely divided untreated technically pure precipitated calcium carbonate. It has a specific gravity of 2.680. Particle size (microns)—2–3, controlled pH—9.0; percent residue—325 mesh—0.114.

MILDEW PREVENTIVE

A positive mold mildew and algea preventive offered by Carolina Aniline & Extract Co is called Mert ZT. Recently perfected, it is to be incorporated in paint, varnishes, lacquers, petroleum solvents and paint thinners. One pint of the material immunizes one gallon of paint. It is odorless, non-toxic to humans, insoluble and does not affect color or working properties of paints or plastics.

PRODUCTS OF AROMATIC SULPHONAMIDES AND FORMALDEHYDE

Condensation products of aromatic sulphonamides with formaldehyde known as Santolite resins are products of Monsanto Chemical Co.

Characteristics of the three types are as follows:

	MS	MHP	K
Color and form	Soft, pale yellow	Hard, brittle, nearly colorless lumps	Soft, viscous resin, nearly colorless
Flash point	295 deg. F.	310 deg. F.	400 deg. F.
Specific gravity at 25 deg. C.	1.355	1.35 (approx.)	1.307
Refractive index	1.5705 ± 0.0015 at 50 deg. C.	1.5095 ± 0.0015 at 30 deg. C. (25% in toluol)	1.5370 ± 0.003 at 50 deg. C.
Solubility	Soluble in practically all organic solvents except petroleum hydrocarbons and varnish oils		
Retentivity* in N/C	Over 100	Over 100	Over 100
Retentivity* in AC/C	Over 100	Over 100	Over 100
Acid Number	Neutral	Neutral	10 Max.

* Retentivity is given in parts per 100 parts by weight of the N/C or AC/C.

INSULATING VARNISH

An insulating varnish has recently been developed by the Irvington Varnish & Insulator Co. It is an internal drying synthetic resinous phenol-aldehyde type varnish that offers substantial electrical, mechanical and application advantages over oxidized type varnishes, as well as more rapid curing at any given temperature than other varnishes of this type. Harvel 612-C solidifies throughout by induced chemical solidification. It can be applied by brush, spraying, dipping or vacuum pressure impregnation. The varnish is dark brown in color and supplied at a specific gravity of 0.870 (31 deg. Baume) measured at 30 deg. C.

SOLVENT TYPE PLASTICIZER

A cyclic ketone, a derivative of isophorone of high molecular weight intended for use as a chemical or solvent type plasticizer, for coating plastics, cellulose derivatives, etc. and as a softener for synthetic and natural rubber is plasticizer C-24 made by Resinous Products & Chemical Co. It is characterized by high plasticizing efficiency, chemical inertness, high boiling point, low freezing point and low vapor pressure. The following data illustrates the properties of this plasticizer:

Distillation range—96% between 200/300° C. at 5 mm.
Boiling point (760 mm.)—Approx. 410° C. (calculated)
Freezing point—Below minus 60° C.
Color—Less than 3 (Gardner-Holdt scale)
Viscosity—Approx. 0.5 poises at 25° C.
Specific gravity—0.875 at 25° C.
Pounds per gal.—7.5
Refractive index—1.475 at 25° C.
Acidity—Negligible
Solubility in water—Less than 0.1%
Solubility—water in C-24:—Less than 0.1%

EMULSIFYING AGENT

An emulsifying agent recently developed by Glyco Products Co. Textile oil emulsions which are unaffected by aluminum sulphate, sulphuric acid and other salts and acids can now be made by the use of Emulgor A.

MONOSTRANDS OF RESIN

Monostrands of Koroseal made by B. F. Goodrich Co. are now obtainable. Among the principal applications of the mono-strands which are made in diameters ranging upward from 15/1000 inches, are men and women's garters, belts, wrist watch straps, etc.

SODIUM TETRAPHOSPHATE

Sodium tetraphosphate is one of the Rumford Chemical Works' most recent contributions to the field of phosphate chemistry. Quadrafos is the anhydrous sodium salt of tetraphosphoric acid.

The chemical formula is $Na_6P_4O_{13}$. The composition is Na_2O—39.6 percent, P_2O_5—60.4 percent. Some of the properties are as follows: specific gravity, 2.55, refractive index 1.48, fusion point (approximately) 600 deg. C., heat of solution at 20 deg. C. (concentration 1 gram per 100 grams of water) 40 calories/gram. It is a mild alkali, is permanently stable and does not change when stored in the dry form. It is slightly hygroscopic and will absorb moisture from the air if exposed in a damp place. When mixed with other materials containing adsorbed water or water of crystallization, special care in selecting the other salts and special mixing procedures must be followed to insure against caking. Solutions of Quadrafos can be held for periods of six months without appreciable loss of their original properties. On excessively long storage there is a slow reversion to orthophosphate. Ability of this material to effectively soften water without precipitation is one of its most important properties.

WILLIAMSBURG COLORS

Colonial Williamsburg colors are now offered by Pittsburgh Plate Glass Co. Authentic color reproduction of paints used in historic Williamsburg, Va., prior to the Revolutionary War are now available in 16 shades and white. In general the Williamsburg paints are strong but grayed down. They contain peculiar overtones to harmonize with the trappings and furnishings of the era, such as rich brocades, ancient leathers, chintzes, etc.

DISPERSED RECLAIMED RUBBER

Water dispersion of reclaimed rubber, Dispersite, has been announced by Dispersions Process, Inc. It is said to be better than latex for certain applications, while in other applications it is a "pinch hitter" for latex.

PROTECTIVE COATING

A new grade of Koroseal paint named Koroplate developed to protect metal surfaces against chemical reactions and recommended for service wherever extremely corrosive conditions disqualify any other kind of paint or coating is announced by B. F. Goodrich Co. The new paint is liquid at room temperatures and requires no heating before application. At ordinary temperatures it can be either brushed or sprayed and can be thinned with either brush or spray thinners when necessary. It is made only in semi-glossy black. The new paint when thoroughly dry is extremely redistant to the action of fumes and vapors from acids, alkalis and salts at room temperatures or slightly above. It resists all acids except concentrated formic and acetic, and is not affected by brass, chrome, nickel, cadmium, zinc, copper, silver or tin plating solutions.

PERSONALITIES

Harlow Bradley

H. A. H. Pray

✦ HARLOW BRADLEY, for many years connected with Allis-Chalmers Mfg. Co., has been appointed supervisor of foreign dealers. In his new capacity, Mr. Bradley's chief duties will be to promote the sale of the company's main line of industrial machinery in foreign countries. His headquarters will be Milwaukee. Mr. Bradley, who is a member of the American Institute of Chemical Engineers, obtained his education in chemical and metallurgical engineering at the University of Wisconsin. He started with the Allis-Chalmers organization in 1915 as a graduate student apprentice and except for service as ensign in the U. S. Navy during the first World War, he has been connected with the company ever since.

✦ EDWARD H. LYNCH and DANIEL G. WELSH, students of the University of Delaware, were awarded first and second prizes respectively in the F. C. Zeisberg Award of the Philadelphia-Wilmington Section of the American Institute of Chemical Engineers. The award is given in memory of Mr. Zeisberg for excellence in the preparation of the report and to be contested for each year by senior students in chemical engineering at Bucknell University, University of Delaware, Drexel Institute of Technology and University of Pennsylvania.

✦ H. E. SMITH, assistant general manager of the Manhattan Rubber Mfg. Division was elected a member of the Board of Directors and of the Executive Committee of Raybestos-Manhattan, Inc., at the recent annual meeting.

✦ THOMAS MIDGLEY, JR. of Worthington, Ohio, and vice president of the Ethyl Gasoline Corp., received the Priestley Medal, an honor awarded each year by the American Chemical Society for both scientific ability and courage.

✦ H. A. H. PRAY has been named head of a new division of electrochemical research at Battelle Memorial Institute, Columbus, Ohio. Dr. Pray, who has had years of experience in physical and organic chemistry as related to industrial problems, has been a member of the Battelle staff since 1934. Previous to that time he held professorships at several universities. He received the B.S. and M.S. degrees from Oberlin College and a doctorate from the University of Wisconsin.

✦ ALMON N. BOWES has concluded the course of instruction at the Army Industrial College in Washington, and has been assigned to duty in the Chemical Warfare Procurement District of New York. Captain Bowes is serving a year's tour of duty as a reserve officer.

✦ SAMUEL R. FULLER, JR., has been appointed chief of the materials branch Division of Production, Office of Production Management. Mr. Fuller, who is president of the North American Rayon Corp. and of the American Bemberg Corp., joined the defense organization in February as chairman of the Production Planning Board which is attached to the Division of Production. He will retain his duties as chairman of the Planning Board. The Board has completed its preliminary period of intensive study and it is not contemplated that it will meet more than several times a month. He was associated with the defense effort during the World War at which time he was in charge of steel and machine tool procurement for the Navy Department.

✦ ROBERT E. DOHERTY, president of the Carnegie Institute of Technology, has been appointed chairman of the Production Planning Board by John D. Biggers, director of the Division of Production, Office of Production Management. Dr. Doherty will replace Samuel R. Fuller, Jr., chairman of the Board since its establishment on February 20. Mr. Fuller was recently appointed chief of the materials branch, OPM, and resigned to devote his full attention to his new duties.

✦ WILLIAM L. BATT, engineer, manager and leader in industry received the 1940 Henry Laurence Gantt Memorial Gold Medal for "distinguished and liberal minded leadership in the art, science and philosophy of industrial management in both private and public affairs." The award was made at a dinner held April 22 at the Engineers' Club in Philadelphia. The medal is awarded annually by a board made up of representatives of the American Society of Mechanical Engineers and the Institute of Management. The first award of the medal was made to Mr. Gantt posthumously in 1929. Other recipients include Fred J. Miller, L. P. Alford, Henry S. Dennison, Horace Cheney, Wallace Clark, Arthur H. Young and Morris H. Leeds.

✦ ROBERT E. DUNHAM has been elected president of the Sunray Electric, Inc., of Warren, Pa. Mr. Dunham resigned as assistant chief lubrication engineer of the Sinclair Refining Co., to accept this new appointment. Prior to his Sinclair connection, he was chief engineer of Hyvis Oils, Inc., in Warren, which company was later absorbed by Sinclair.

✦ B. J. BRUGGE has been appointed by Lincoln Electric Co. as its welding consultant and engineer of Washington, D. C. He will be engaged in consulting work having to do with the application of arc welding in the National Defense Program, and will be available for such work with all governmental departments.

✦ ANDREW E. BUCHANAN, JR. has been appointed division production manager for the plants of Remington Arms Co., Inc. at Bridgeport, Conn., Ilion, N. Y., Kings Mills and Findlay, O. After graduating in chemical engineering from Lehigh in 1918, Mr. Buchanan joined the du Pont company and was assistant and later associate editor of *Chem. & Met.* until he returned to Lehigh in 1923. He was appointed research director for Remington Arms in 1936 and was promoted to technical director in 1939. With the expansion of the company's military business in January, 1941, Mr. Buchanan became assistant production manager in the procurement of supervisory personnel, which position he held until his present promotion.

✦ KENNETH MENKE has been transferred from assistant supervisor in the Nitrate Division of the Monsanto, Ill., plant of the Monsanto Chemical Co. to the research department in St. Louis.

✦ L. P. WENZELL has been transferred from the research department of the Monsanto Chemical Co. at St. Louis to technical assistant in the chlorine department at Monsanto, Ill.

H. Boezinger

✦ H. BOEZINGER, for the past several years district manager in Los Angeles of the Pittsburgh Equitable Meter Co. of Pittsburgh, Pa., and the Merco-Nordstrom Valve Co. of Oakland, Calif., has been elected a vice president of the latter company. Mr. Boezinger is a graduate of Stanford University. Prior to his affiliation with Merco-Nordstrom Valve Co., he was engaged in petroleum engineering in both the San Joaquin Valley and Southern California.

✦ WILLIAM J. KNOX, JR., of Hammond, Ind., senior reserve officer of Lake County, recently left his executive position with the International Smelting & Refining Co. in East Chicago, for a year's extended active duty with the armed force at Fort Knox, Ky. Col. Knox saw overseas service as a Captain in the Chemical Warfare Service during the last war and since that time has been active in the Chemical Warfare Reserve.

✦ RALPH H. MANLEY, who has been assistant director of the Armour Research Foundation as well as associate professor of chemistry at the Illinois Institute of Technology, recently resigned to become senior chemist in the oil and protein division of the Northern Regional Research Laboratories of the U. S. Department of Agriculture at Peoria.

✦ STANLEY M. WALAS has joined the chemical engineering division of the Armour Research Foundation where he is engaged in pilot plant development in food processing. Formerly with the

Long Manufacturing Division of Borg-Warner Corp., his most recent work has been on the filtration of compressible materials at the University of Michigan.

✦ WILLIAM C. KRESS has been added to the staff of the Ceramics Division of Armour Research Foundation to conduct enamel research. He is a graduate of the University of North Carolina and was formerly with the Tappan Stove Co. of Mansfield, Ohio.

✦ ARCHIE CRAMER, formerly research chemist on the staff of Carnegie Institute of Technology, from 1939-1942, resigned to join the Miner Laboratories. His new duties will involve chemical research on soybeans.

✦ M. VAN WINKLE, who was formerly associated with the Cities Service Oil Co. at Okmulgee, Okla., is a recent addition to the research staff of the Standard Oil Co. of Indiana at Whiting.

✦ CLIFFORD A. NEROS, who was with Styco Smelting & Refining Co., Minneapolis, Minn., has recently joined the staff of the American Can Co., Maywood, Ill.

Marston T. Bogert

✦ MARSTON T. BOGERT'S portrait painted by Irving Wiles, was presented to Columbia University May 2, at a dinner at the Chemists' Club, New York City. Professor Bogert's Ph.D. graduates presented the portrait to the university.

✦ RAYMOND B. SEYMOUR, formerly with Atlas Mineral Products Co., Mertztown, Pa., is now with Monsanto Chemical Co., Dayton, Ohio.

✦ ROY IRVIN recently accepted a position in the chemical laboratory of the Red Star Yeast Co.

✦ HAL P. LUNDGREN has accepted a position as associate chemist at the Western Regional Research Laboratory of the U. S. Department of Agricul-

ture, located at Albany, Calif. Dr. Lundgren expects to begin work in the protein division. Since 1937 he has been a research associate at the University of Wisconsin.

✦ L. A. CURTIS has been transferred from process research and development work in the chemical engineering laboratory of the Midland, Mich. plant of The Dow Chemical Co. to production engineering work in the magnesium recovery plant of the Texas division of the same company.

Thomas K. Sherwood

✦ THOMAS K. SHERWOOD, associate professor of chemical engineering at Massachusetts Institute of Technology, received the William H. Walker award of the American Institute of Chemical Engineers at its recent meeting in Chicago, Ill. Dr. Sherwood received his B.S. degree from McGill University in 1923 and his S.D. from Massachusetts Institute of Technology in 1929.

✦ NOAH S. DAVIS, JR. has resigned his position as supervisor in the New Process Development Section of the R. and H. Chemical Division of the E. I. du-Pont de Nemours & Co. and has accepted the appointment of research supervisor in the J. B. Ford Co. of Wyandotte, Mich.

OBITUARY

✦ GEORGE H. DANNER, president and general manager of Pittsburgh Piping & Equipment Co., Pittsburgh, Pa. died at the age of 66 on April 11 in Pittsburgh. Mr. Danner was one of the original founders of the company nearly 40 years ago and served as president since its organization.

✦ WILLIAM T. RANDALL, Philadelphia sales engineer of the Pangborn Corp., Hagerstown, Md., died suddenly of a heart attack on April 14 while on an Easter visit to his summer cottage at Pittsfield, Vt. He was 57 years old. A native of New England, Mr. Randall settled early in Philadelphia. He joined the Pangborn Corp. as Philadelphia representative in 1919 and has been widely known in that district during the past 22 years.

Chem & Met MEETINGS & CONVENTIONS

A.C.S. Convenes in St. Louis

From a total of nearly 480 papers presented before eight different organizations in all parts of the country, the editors of *Chem. & Met.* present herein factual abstracts of the 19 papers considered to be of most interest and value to chemical engineers and industrial chemists engaged in all phases of the profession.

DEFENSE STATUS OF CHEMICALS

Of interest to chemical engineers is the present status of chemicals in National Defense, as outlined at the American Chemical Society by E. R. Weidlein of Mellon Institute, M. L. Crossley of the American Cyanamid Co., C. L. Parsons, secretary of the American Chemical Society, and others. Some of the most pertinent data are summarized in the following paragraphs.

Nitrogen—Most serious of defense problems of chemical industries will be to supply nitrogen for all munitions, agricultural, and industrial purposes after 1941. Three new synthetic nitrogen plants have been constructed, imports of Chilean nitrate have been greatly increased, and in addition, stock balances of ammonia are being accumulated. The domestic supply of nitrogen comes mainly from production of synthetic and by-product ammonia, from Chilean nitrate, and from a small amount of cyanamid from Canada. The present concern is the fact that it requires 18-24 mos. to build a synthetic ammonia plant and only 8-9 mos. to construct a munitions plant. Hence it might be necessary to curtail use of nitrogen for industrial and certain agricultural uses in order to meet the munition demand and also to substitute Chilean nitrate for synthetic ammonia or its derivatives for certain uses in order to release synthetic ammonia for more strategic uses.

Toluene—Ample supplies of toluene, basis of TNT, are assured, as it is estimated that production by the petroleum industry could be increased to 100,000,000 gals. per year. Several petroleum companies are proposing toluene plants in units of 5,000,000 gals.

Petroleum—Estimated peace-time demand for petroleum products during 1941 will be 8-9 percent greater than the record for 1940, yet the petroleum industry will have no difficulty in supplying every foreseeable demand. The only possible bottleneck is in tanker transportation to the East coast, as 95 percent of Atlantic coast petroleum consumption is delivered, either as crude or refined product, by tanker. Movement from the Gulf alone amounts to about 1,350,000 bbls. per day and requires a fleet of 260 domestic tankers. Eight large tankers have already been requisitioned by the Navy. In event of a naval war in the Atlantic involving use of convoy system, there probably would be difficulty in supplying Atlantic coast civilian gasoline needs. To correct this situation, more storage tanks are being constructed in the East, more tankers are being built (25 are expected to be delivered during 1941), and pipeline and barge transportation facilities are being considered to eliminate tanker haul around Florida.

Sulphuric Acid—The sulphuric acid situation is promising, but it will be necessary to increase oleum capacity to meet the munitions demand.

Antimony Sulphide—This essential ingredient of primers is obtained from China over the Burma road. Efforts to make a synthetic product from Bolivian or Mexican ores have not been promising, as primers from these ores do not have the same sensitivity as the Chinese antimony sulphide. This problem has been presented to the National Research Committee for further investigation.

Carbon—Production facilities for gas-mask activated carbon are inadequate to satisfy the Chemical Warfare Service. New plants to increase capacity are being built.

Drugs—Large stores of important drugs have been accumulated and 2-3 years' supplies of opium, iodine, and quinine are available. In chemotherapy, sulfanilamide and its derivatives will be valuable in combating infections of both civilian population and military forces.

Chemical Manpower—The supply of chemists and chemical engineers does not now meet the demand, it was stated. Demand is increasing but prospective output is falling more and more rapidly below normal. Competitive bidding for chemists has already begun and a large portion of the class of 1941 has already been placed. Special efforts must be made to keep chemically-trained manpower of the nation "in the production army" where its talents can be best utilized.

LOW-TEMPERATURE CARBONIZATION

The Hayes Process for carbonizing coal at a low temperature, described by Guy V. Woody, Allis-Chalmers Mfg. Co., before the American Chemical Society in St. Louis, involves the use of a 20-in. diameter revolving retort mounted in a furnace and heated externally. To provide long travel and resultant rapid carbonizing, a screw 16 in. in diameter is so mounted inside the drum that it comes in contact with the periphery of the inside bottom of the drum. This screw has a forward and reverse motion, the forward motion being about 1 ft. per min., but with a total travel of about 220 ft. Since the retort is approximately 20 ft. long, coke is produced from the coal in about 20 minutes. This time is a variable factor depending upon the coal used and the volatile content desired in the coke.

Because of the rapid rate of coking and internal quenching, greater amounts of byproducts are obtained from this process than from processes of other types. Because of comparatively low capital cost, low amount of labor and power, and increased yield of byproducts, the cost of low-temperature coke made by the Hayes process was indicated as unusually low. Two forms of low-temperature coke can be produced—namely, char for use in

CALENDAR

MAY 19-21, American Institute of Chemical Engineers, semi-annual meeting, Edgewater Beach Hotel, Chicago, Ill.

MAY 19-22, American Petroleum Institute, mid-year meeting, Mayo Hotel, Tulsa, Okla.

JUNE 9-10, National Ass'n. of Insecticide and Disinfectant Manufacturers, Inc., mid-summer meeting, Hotel Edgewater Beach, Chicago, Ill.

JUNE 16-20, American Society of Mechanical Engineers, semi-annual meeting, Kansas City, Mo.

JUNE 23-27, American Society for Testing Materials, annual meeting and exhibit, Palmer House, Chicago, Ill.

stokers and briquetted coke for use in stoves, hand-fired furnaces and fireplaces.

Low-temperature carbonization of coal by the Disco process was described by Caleb Davies, Jr., and C. E. Lesher of the Pittsburgh Coal Carbonization Co. Low-temperature coke is being made by this process in commercial operations at Pittsburgh from high-volatile coking coal. The fuel is claimed to be smokeless, free-burning, of firm structure and easily ignitable.

Coals from Illinois, Oklahoma, Utah, Colorado, Kentucky, West Virginia, Ohio and Pennsylvania have been tested and it was found that any coal with suitable coking properties can be processed by the Disco process. The tar, which is the principal byproduct, is chemically unusual but its products have given excellent service in most branches of the coal tar industry. Disco tar acids are now a potential source of raw material for resins in both plastics and varnish industries.

PAINTING MAGNESIUM ALLOYS

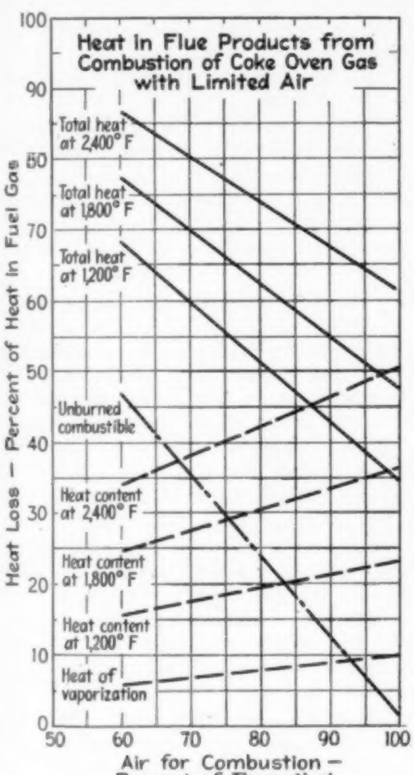
Increasing use of magnesium alloys in industrial fields, especially the aircraft industry, has focussed attention on this metal. For most applications, there is need for serviceable protective coatings. Paint performances, reported upon by Robert I. Wray, Aluminum Co. of America, New Kensington, Pa., before the American Chemical Society in St. Louis, was directly affected by resistance to corrosion of the various magnesium alloys. Adequate surface treatment prior to painting was found to be very important. Numerous methods of surface treatment were investigated, but the best protection was attained with the "Chrome Pickle" treatment followed by a sealing treatment in hot dichromate solution or by means of a short dip in hydrofluoric acid followed by a sealing treatment in hot dichromate solution.

Zinc chromate primers made with phenolic resin varnishes of moderate oil length showed outstanding performance, particularly when followed by three coats of aluminum paint made with the same vehicle. It was necessary to employ three finishing coats over the primer to achieve adequate protection under severe service conditions. Phenolic resin varnishes of 20–25 gal. oil length proved much better than longer oil varnishes. Order of failure of the various coatings in the alternate immersion was found to agree quite well with that obtained in atmospheric exposure at the seacoast, although failure occurred at a much more rapid rate in the accelerated test. In certain instances, the ratio of time of failure was as great as 1:50. In industrial atmospheric tests it has not been uncommon to obtain satisfactory protection for five or six years. By proper selection of alloys, surface treatment, and painting, it has been possible to obtain satisfactory protection on magnesium alloys for several years, even under relatively severe service conditions.

GAS FURNACE FLUE LOSSES

Calculation of flue losses from industrial gas furnaces using special atmospheres, especially when the combustion products are treated to remove water vapor and CO_2 was reported upon by W. R. Teller of the A.G.A. Testing Laboratories before the American Gas Association conference in Baltimore.

Large quantities of water vapor and CO_2 normally contained in a flue gas mixture prevent its use as a strictly non-oxiding atmosphere, particularly for plain carbon steels. In bright annealing or clean heat treating, it is therefore necessary to treat partially burned gases by removing water vapor and CO_2 before utilizing as a protective atmosphere. Such treatment generally takes place at room temperature or less and a great deal of heat is lost unless heat exchangers or other heat-saving devices are employed.



If flue gases are to be cooled to room temperature, the quantity of heat to be removed from products of 1 cu.ft. of fuel gas may be read from the accompanying graph which shows the quantity of heat above 60 deg. F. Volumes of flue gases before and after purification may also be estimated by means of curves. Since furnaces employing purified atmospheres must be operated under a slight positive pressure to prevent seepage of air into the treating chamber, some loss of atmosphere must be expected. If this loss is determined in terms of cubic feet, the amount of heat loss in this manner may be estimated by reference to the proper curve. Since most of the heat originally contained in the unpurified flue gases is removed during purification, these final heat losses are relatively small.

INJECTION MOLDING

According to H. W. Paine, M. L. Macht and W. E. Rahm of the E. I. duPont de Nemours & Co., Inc., Arlington, N. J., at the American Chemical Society in St. Louis, the process of injection molding has only recently achieved wide popularity, primarily because of the lack of a suitable, inexpensive, heat-stable plastic, capable of being softened by heat. After the advent of heat-stable cellulose acetate, injection molding developed rapidly. Six advantages of the injection molding process which result in lower production costs for articles of higher quality are:

1. High speed of production made possible from rapid press operation as well as the lack of necessity for alternately heating and chilling, or for curing.
2. Low mold cost made possible by smaller number of cavities required per mold for a given production.
3. Greater convenience in setting up the dies, which are of lighter construction than those used in compression molding.
4. Lower finishing cost after molding, since flash, considered inevitable in compression molding, is not formed in a well-made injection mold.
5. Smaller loss of material, since defective articles as well as material from the channels connecting the cylinder and the mold can be re-used.
6. High thermal efficiency of the system, as the heating cylinder and chilled mold are maintained at constant temperatures throughout the cycle.

The economy and speed of injection molding as compared to compression molding commonly used for thermoplastics and rubber are illustrated by a certain automobile ornament which was first produced by compression. Under optimum conditions, 20-cavity molds were required to produce 170 pieces per hour because of time required for heating the mold, for heating through the cold powder, and finally for chilling the piece prior to its ejection. By the injection process, a 2-cavity die produced the same number of pieces per hour and less finishing was required, since there was no flash to be removed.

Use of injection molding technique for thermosetting compounds, such as phenol-aldehyde resins, has been studied experimentally. There has been little or no commercial use of this technique, although apparently satisfactory articles have been produced by modifying the technique outlined for thermo-plastic materials to the extent of using comparatively low cylinder temperatures in conjunction with elevated die temperatures to cause a final setting up in the die rather than in the cylinder.

PLASTICS FOR PURIFYING WATER

According to Robert J. Myers and John W. Eastes of the Resinous Products & Chemical Co., Inc., Philadelphia, Pa., before the April meeting of the American Chemical Society, the recent development of synthetic resins which exhibit ion-exchange properties has opened a new field of application which promises unique uses in purification of

water and other fluids, in recovery of valuable substances, in removal of undesirable impurities, and in many special uses. Phenol-aldehyde resins can be prepared to function as cation-exchangers and may be used in the sodium cycle for removal of hardness-producing ions such as calcium, iron, etc., or may be used in the hydrogen cycle to replace all cations with hydrogen. Again, amine-aldehyde resins may be prepared which function as acid-absorbents, or "anion-exchangers", and may be used to recover or remove acid radicals from solution. The treatment of water by a cation-exchange resin and then by an acid-absorbent resin, leads to the production of a high quality "distilled water" which compares favorably with laboratory distilled water in purity.

Resinous ion-exchangers were said to offer the following advantages: high capacity, high exchange velocity, excellent stability (both mechanical and chemical) to acids, alkali and heat, uniformity of quality, low operating cost, freedom from "leakage" of ion being removed and wider fields of application.

Resinous ion-exchangers may be used in the softening of water for industrial, municipal, and domestic use. They may be used in the partial or complete removal of dissolved salts from water, sugar solutions, protein solutions, biological and pharmaceutical media. They are of value in the recovery of traces of copper and other valuable metals from dilute solutions and in the removal of iron and objectionable acids from water and industrial products such as enzyme extracts, dyestuffs, pigments, sugar solutions, and pharmaceutical preparations. Other applications undoubtedly will appear in the very near future.

Synthetic resins have been prepared with a wide range of physical and chemical properties and many of these have been examined and compared with the older exchange adsorbents. Results indicate a superior behavior and a unique combination of properties not possessed by any material hitherto used for the applications thus far examined, reported the authors.

SUPERPHOSPHORIC ACID

Pilot plant development of a new process for manufacturing phosphoric acid was described by J. H. Walthall and M. M. Striplin, Jr., of the Tennessee Valley Authority, at the St. Louis meeting of the American Chemical Society. Phosphorus is burned with dried air and the resulting phosphorus pentoxide vapor is absorbed in concentrated aqueous solutions containing about 85 percent phosphorus pentoxide (superphosphoric acid). Concentrated solutions of low water vapor pressure, and dried air are employed to avoid formation of an acid mist resulting from hydration of the phosphorus pentoxide in the vapor phase. The absorption step is carried out at temperatures above 260 deg. C. to prevent

condensation of phosphorus pentoxide to the solid phase. The resulting phosphorus pentoxide solution is a viscous liquid which can be diluted with water to yield either pyrophosphoric acid or orthophosphoric acid, depending upon the quantity of water used for dilution.

NEW SOURCE OF LITHIUM CHLORIDE

The increasing importance of lithium and its salts has focussed attention on methods for their economic production from lithium-bearing materials. Lepidolite is a relatively low-grade but abundant lithium ore which averages only 3.5 percent Li_2O. Considering the possibilities of industrial utilization, the reaction between pulverized lepidolite and hydrogen chloride at high temperature was investigated by George O. G. Lof and Warren K. Lewis of the University of Colorado and Massachusetts Institute of Technology and reported upon before the American Chemical Society. By passing HCl over heated ore, reaction takes place; vaporization of the chlorides and their removal from the excess gas permit recovery of lithium chloride in aqueous solution. Using a temperature of 935 deg. C. and a reaction time of 13 hr., a lithium chloride recovery greater than 95 percent can be obtained. The yield increases with rise in temperature and reaction time, provided the ore is not melted.

If the gas is used in sufficiently great excess, recovery is practically independent of HCl flow per unit quantity of ore. The excess can be removed by recirculation. The yield is also independent of particle size in the range studied. Presence of air or water vapor in the gas lowers the yield. Percentage yields of HCl are approximately equal to lithium yield, whereas alumina and silica yields are below 10 percent of that in the ore. The distilled product contains one part LiCl, 1.7 parts KCl, 0.5 parts $AlCl_3$, and 1.5 parts $SiCl_4$.

CALCIUM METAPHOSPHATE

In the manufacture of calcium metaphosphate, rock phosphate is treated with P_2O_5 at elevated temperatures. To study the factors affecting this reaction, pellets of rock phosphate of different compositions, of fluorapatite, and of lime were suspended in a tube furnace in a stream of gas containing P_2O_5. The temperature, gas velocity, P_2O_5 concentration, and water vapor concentration were varied and results reported upon by G. L. Frear and L. H. Hull of the Tennessee Valley Authority before the American Chemical Society in St. Louis.

At the instant of initial exposure, the rate of reaction of P_2O_5 with the pellet was nearly independent of temperature in the range of 700–1100 deg. C., varied with the gas velocity, and was directly proportional to the P_2O_5 concentration, indicating that transfer through the gas film was the rate-determining step. After a period of exposure that varied

with the conditions, the rate of this reaction greatly decreased, became more dependent upon temperature and less dependent upon gas velocity and ceased to be proportional to P_2O_5 concentration, indicating that transfer through the coating of liquid product forming on the pellets was a rate-determining step. The rate of reaction of P_2O_5 with the different materials decreased in the order: lime, fluorapatite, rock phosphate. The observed rates were not appreciably affected by the concentration of water vapor.

AMERICAN DRYING OILS

The present status of drying oils and methods of extending use of these by fractional distillation was reported upon by D. M. Flick of Armour & Co., before the Seventh Annual Chemurgic Conference in Chicago during March. Domestic production of lard, cottonseed, soybean, peanut and corn oils make us practically self-sufficient in edible fats and oils, but production of inedible fats is not adequate and in this class our deficiency lies in the field of the so-called drying oils. These are chiefly tung, perilla, castor, and linseed oils. The first three are almost 100 percent imported, and more than half of our linseed oil requirements depend upon imports. Total annual imports of these four oils amount to approximately 500,000,000 lb. Tung oil comes from China; perilla from Japan; castor from Brazil; and linseed from Argentina.

A comparison of saturated and unsaturated fatty acids in linseed, tung and soybean oils, and lard shows why these oils are either drying, semi-drying or non-drying.

	Non-Drying Acids %	Drying Acids %
Linseed	13.5	86.5
Tung	20.0	80.0
Soybean	45.2	54.8
Lard	89.6	10.4

Although soybean oil contains 55 percent drying acids, it has not been used to any large extent for drying oil purposes in spite of the scarcity and high prices of these oils, due to the difficulty of recovering these acids in soybean oil for use in paint and varnishes.

A major improvement over simple distillation for refining mixed fatty acids has been the development by Armour & Co. of the fractional distillation process. In this process distillation is carried out so that not only are the non-volatile impurities removed, but the component fatty acids are separated into purified fractions. The outstanding advantage of fractional distillation to industry is that it replaces the uncertain mixtures obtained by mechanical pressing with a series of pure fatty acids possessing fixed and reproducible properties. Thus, when combined with glycerine, the drying fatty acids from soybean oil can be used directly in paint, varnishes, linoleum and core oils. By application

of fractional distillation to marine oils it has been possible to utilize both the saturated and the unsaturated components. Thus the process of fractional distillation is enabling American manufacturers to use fractions of domestic oils to replace foreign drying oils which are becoming more difficult to obtain. Another result is that today many fractionally distilled acids are available at little or no greater cost than ordinary straight-distilled mixed acids. Fatty acids that previously had been available in only limited quantities at fancy prices are now shipped in tank-car quantities at commercial prices under the trade-name "Neo-Fat."

TESTING MIXING EQUIPMENT

Defects in ceramics ware could have been prevented if standard control tests had been used to indicate the degree of batch mixing obtained, according to Wayne C. Brownell of New York State College of Ceramics before the annual meeting of the American Ceramic Society in Baltimore. A method of sampling was developed which proved highly satisfactory. The dry mixed batch was dumped onto a number of sampling boards. Each board contained 96 gelatin capsules inserted into drilled holes and when these capsules were filled, the covers were placed on them.

Two mechanical mixers of different types were tested to compare their individual performance. Batches containing fire clay and grog were mixed in a Reid mixer. Florida kaolin and sand, grogs of different particle size, and batches containing dyes were mixed in a rotating cone mixer equipped with stationary blades. The Reid mixer proved to be most efficient when mixing batches of small grain size.

The degree of mixing followed certain mathematical laws. When deviations from the mean were plotted against size of the sample, the curve could be expressed by the equation

$$y = AX^b$$

when y is deviation from a mean, X is size of sample, and A and b are constants. When X was equal to 1, A could be considered the mixing factor. Smaller values of A indicate more perfect mixing. A normal distribution curve is the result of plotting the number of samples against the deviation. Batches of unlike character require different mixing treatment and the time required varies with several factors.

PACKAGE ADHESIVES

Various factors influencing choice of adhesives for different packaging problems were reported upon by Frank C. Campins of National Starch Products, Inc., before the Packaging Conference of the American Management Association in Chicago, April 1–4. The "age-proofing" factors in packaging require a particular type of adhesive. As a class, aqueous adhesives cannot be used for water-repellant materials, as they cannot spread on or adhere to the

surface. Neither can the aqueous adhesives be used for moisture and vaporproof materials, as the moisture cannot diffuse through this stock to allow proper drying. Such water-repellant and moistureproof materials demand organic solvent types of adhesives or thermoplastic methods of adhesion. On the other hand, grease-proof paper and parchment do not allow organic solvent adhesives to dry, and hence aqueous adhesives or heat-sealing methods must be used.

In general, adhesives can be divided into two classifications: (a) solvent or remoistening types, which include aqueous glues and solvent adhesives and (b) hot melt or heat-softening types, which include the hot flexible glue types and the synthetic resins. Most adhesives can be applied by either direct application, usually in a continuous web by a narrow disc, or by transfer through the use of two glue rolls, one of which is a segmented roll. Another type of transfer is where the applicator works in printing press fashion and has added cooling and evaporating surface.

PLYWOOD FOR PLANES

Resin-bonded plywood, according to L. Klein of the Resinous Products & Chemical Co., Philadelphia, Pa., before the American Chemical Society, is already playing an important part in construction of primary and secondary trainers where the use of metal can be greatly reduced. It is also important in production of bombers and transport planes where sub-assemblies such as bomb-bay doors and floors are constructed of plywood. These uses have been made possible largely because of a phenolic resin film in sheet form known as "Tego Film". The process of making plywood using resin film is simple. Sheets of film about 0.002 in. thick are interleaved between thin veneers of birch, spruce or mahogany and the assemblies are placed in the hot press at 300 deg. F. for two to three minutes. The panel is withdrawn from the press without cooling to complete the process of preparing the plywood.

This product is absolutely water-and mold-proof and the bond between the plies is stronger than the wood itself. The panels can be saved, machined, and handled like ordinary wood, and they can even be bent and formed to a certain extent after first softening in boiling water. The use of plywood for planes does not introduce a serious flammability hazard. The major hazard is the gasoline and if this becomes ignited, it matters little whether the plane is made of metal, wood, fabric or plywood. Recent developments in adhesives, which are generally of the urea-formaldehyde rather than the phenol-formaldehyde type, permit bonding the various parts of the plane to produce strength and resistance far in excess of those attained by use of blood, casein or animal glue.

Of great potential significance is the

development of the so-called "plastic" plane. Actually, on a weight basis, the "plastic" plane contains one part of resin to nine of wood. The plywood is resin-bonded over a form or die rather than in the flat condition. The potential advantage in speed of assembly and reduction of aerodynamic drag due to smoothness are obvious. Announcement of a new type of phenolic resin which cures at a lower temperature than those hithertofore available, thus materially increasing the life of rubber bags now used in this process, should help developments in the field.

MINERAL WOOL FROM COAL WASTES

Part of the work of the Anthracite Industries Fellowship at Mellon Institute has been the problem of utilization of anthracite wastes, reported R. C. Johnson, Industrial Fellow, in a Mellon Institute Technochemical Lecture, April 3. Both ashes and colliery refuse are of potential interest as raw materials for various industries because of their low cost, availability in large amounts near eastern markets, their substantial fuel content and certain physical properties.

During an investigation of various types of insulating and acoustical materials from anthracite ashes, it was discovered that high-grade mineral wool can be produced from such ashes, or from colliery refuse, by adding a suitable flux, such as limestone, and then melting the resulting mixture to form a fluid glass which can be blown into white mineral wool.

A new type of mineral-wool furnace was built at the Institute, into which a mixture of colliery refuse and ordinary limestone is charged. Operating principles of this furnace resemble in some respects the operation of a blast furnace and a slagging gas producer. It has been operated to produce 100 lb. of mineral wool per sq.ft. of hearth per hour, and thus far the maximum burning rate has been limited by capacity of the blower that supplies air. To operate this furnace, the refuse-limestone mixture is charged into the top and air for combustion is supplied by blower. A small amount of steam may be used to control temperatures and the composition of the fuel gas that is produced in the furnace. The molten product collects at the bottom of the furnace and flows in a small stream from a spout into high pressure steam jets that form the mineral wool in streamers. Patent applications have been filed covering the process and product.

Manufacture of mineral wool from anthracite colliery refuse (assumed to cost $1 per ton at the wool plant) appears to be about 20 percent cheaper than the manufacture of slag wool and about 50 percent cheaper than rock wool. These estimates are for the loose wool before fabrication. Actual manufacturing costs will depend upon size of plant and tonnage sold. Both colliery refuse and anthracite ashes

are suitable for manufacture of mineral wool. Ashes are available close to mineral wool markets, but the physical character of household ashes is such that special treatment is needed and semi-plant scale tests have not yet been made. From information available, it appears that this new process has attractive commercial possibilities.

FORTIFIED FOODS

The National Research Council and other organizations have urged millers and bakers of this country to start early production of a new flour and bread enriched in vitamins and minerals. Recently, the millers and bakers agreed to start production as soon as possible. According to various statements, addition to flour should consist of:

Required Ingredients	Milligrams per Lb.
Vitamin B_1 (thiamin)	1.66-2.5
Vitamin B_2 (Riboflavin)	1.22-1.83
Nicotinic Acid or Amide	6.15-10
Iron (elemental)	6.15-24.6
Optional Ingredients	
Calcium	492-2,000
Vitamin D	246-369 I.U.

Practical applications of fortification and restoration of processed foods in the baking and dairy industries were reported upon by James A. Tobey and W. H. Cathcart before the American Chemical Society in St. Louis last April. The organized milling and baking industries have accepted this program as a desirable contribution to national defense and as a permanent contribution to public health. Bread can be nutritionally enriched by the use of enriched flour, enriched yeast, a "master ingredient" and by other methods and combinations of these methods. Also discussed was the enrichment of milk with Vitamin D and the function of added Vitamin A to margarine.

According to C. A. Elvehjem, the following figures may be used as a guide for daily requirements of the better known nutrients:

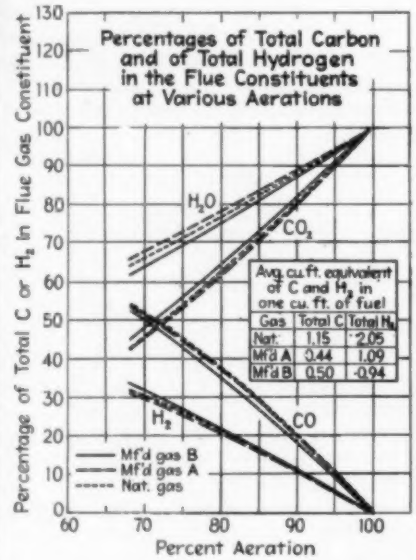
Proteins	70 g.
Calcium	0.7 g.
Iron	12 mg.
Vitamin A	4,000-5,000 I.U.
Vitamin B_1	1.5-2.0 mg.
Vitamin C	50-75 mg.
Riboflavin	2-3 mg.
Nicotinic acid	10-15 mg.
Vitamin D	400 I.U.

The general problem of fortification and restoration of processed foods was discussed by R. R. Williams, who warned that artificial reinforcement should be limited to staple foods and kept within the bounds of those kinds and quantities of vitamins which are indigenous to the food in question.

FLUE GAS COMPOSITION

Newly developed technical information of value in applying industrial gas, with particular reference to composition of flue gases resulting from combustion of gas with a deficiency of air, was reported upon at the American Gas Association conference in Balti-

more last March by W. R. Teller of the A.G.A. Testing Laboratories. Controlled heating atmosphere is essential in many modern heat-treating processes because of need for exact oxidizing, reducing, or neutral conditions. The simplest and most efficient method of establishing this control with gas is to design equipment which will not only supply heat necessary for the desired reaction, but will also deliver gaseous constituents in the flue gases in proportions required.



Heating operations are relatively simple if oxidizing atmospheres are desired. If reducing or neutral atmospheres are desired, the problem becomes more complex. There are many industries where these atmospheres are successfully utilized, but basic principles are less completely understood than for combustion under oxidizing conditions. Results of extensive experiments on factors influencing flue gas composition were summarized as follows:

1. Variables such as flue gas temperature, input rate, or combustion chamber wall temperature, were found to have a relatively minor effect on concentrations of flue gas constituents formed at any given degree of aeration.
2. Oxygen may be practically eliminated from flue gases by reducing the air supplied for combustion to 95 percent or less of that theoretically required for complete combustion.
3. Fuel gas can be burned at aeration close to the lower combustible limit without more than traces of unburned hydrocarbons appearing in the flue products.
4. Flue gas composition which will be produced by combustion of a given fuel gas at a given aeration may be estimated from the fuel gas analysis, since it was found that amounts of CO_2, CO, hydrogen and water vapor formed by combustion were a function of the amounts of total carbon and of total hydrogen (either free or combined) in the fuel gas.
5. Where it is desirable to burn fuel gas with least possible air supply to produce maximum quantities of reducing gases, CO and hydrogen, careful attention should be given to both heat loss characteristics of combustion tubes or chambers and to design of burner.

SELECTIONS FROM FOREIGN LITERATURE

PHOSPHOR BRONZES

EFFECTS of progressively increasing cold working on hardness, annealing behavior and mechanical properties of phosphor bronzes have been studied with seven alloys. The tin and phosphorus concentrations in these alloys were varied from the lowest to the highest figures allowed in British Standard Specification No. 407. Density, thermal expansion, thermal conductivity and electrical conductivity were determined.

Grain size after comparable cold working and annealing did not vary appreciably among the seven alloys. Increasing tin content slightly raises initial softening temperature while increasing phosphorus content lowers it. Cold working has more effect, and gives stronger, harder products in high tin than in low tin alloys. Increasing phosphorus content from 0.02 to 0.4 percent has similar but much smaller effects. Neither composition nor cold working had any considerable effect on modulus of elasticity. In the annealed alloys rising tin content (from 3.11 to 7.31 percent) increases tensile strength, elongation and hardness, but decreases the reduction-in-area values.

Digest from "Physical Properties and Annealing Characteristics of Standard Phosphor-Bronze Alloys," by Maurice Cook and W. G. Tallis, *Journal of the Institute of Metals* **67**, 49, 1941. (Published in England.)

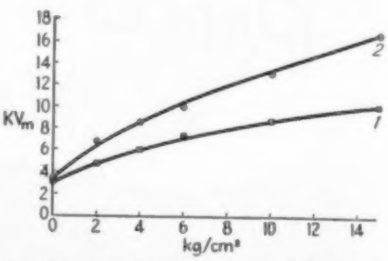
BLAST FURNACE SLAG AGGREGATES

BLAST FURNACE slag is mainly composed of the oxides of calcium, magnesium, silicon and aluminum, with minor proportions of iron, manganese and titanium oxides. Small amounts of sulphides, especially calcium sulphide, may also be present. As an ingredient in concrete, aggregate made from blast furnace slag gives good strength if unit weight of the concrete is kept up to 70 lb. per cu. ft. or higher. More water is required than for similar sand and gravel concretes. The sulphur content of slag apparently does no harm unless too much of it is allowed to oxidize to sulphate. New slag gives as good results as old bank slags. In fire resistance slag concrete is superior to gravel concrete. Aside from its use in concrete, slag aggregate is excellent for use in road construction.

Digest from "Blast Furnace Slag Aggregates in Building and Road Construction," by T. W. Parker, *Chemistry and Industry* **60**, 59, 1941. (Published in England.)

GLASS FIBER INSULATION

THE HIGH resistance of glass fabric to chemicals and heat makes glass fiber a promising material for electrical insulation under exposure to ozone, nitrogen oxides and other products of electrical discharges in high voltage installations. Breakdown tests have therefore been made with glass cloth in which the fibers occupied about 40 percent of the volume of the cloth. Under normal conditions the breakdown voltage of glass cloth proved to be of the same order of magnitude as in an air gap of the same thickness. In a uniform field the breakdown strength of the cloth itself may be lower than for air alone, but the difference may be compensated by the increase in breakdown voltage due to deficiency of charge carriers in the restricted vol-



Breakdown voltages of glass cloth in nitrogen. 1—two layers of glass fiber, thickness 1 mm.; 2—eight layers of glass cloth, thickness 0.8 mm.

ume of the pores. Breakdown strength can be increased by impregnating the cloth with certain varnishes, but this has the disadvantages which go with organic insulating materials. Breakdown strength can also be increased by using the glass cloth in a compressed gas such as nitrogen, thus retaining the inherent advantages of glass cloth as such. Several thin layers of fabric give a higher breakdown strength than one or two thicker layers.

Digest from "Dielectric Properties of Glass Cloth in Compressed Gases," by B. M. Wul, G. M. Kovalenko and J. M. Parnas, *Journal of Physics (USSR)* **3**, 321, 1940. (Published in Russia.)

SOLVENT RECOVERY BY ADSORPTION

"SUPERSORBON" is a shaped active carbon, in granules about 3 to 4 mm. in size. It is activated by the zinc chloride process. Its use has been developed to a high level of mechanical and thermal efficiency, taking full advantage of capillary condensation as an aid to increased recovery capacity. Steam was found to be the best desorption agent. The struggle between batch and continuous processes has so far found batch processes in the lead, not so much because of disadvantages in continuous operation as because its technical problems have not yet been solved.

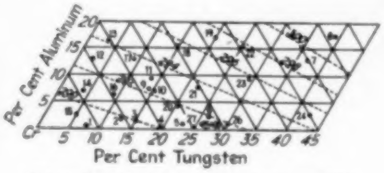
In its present state of efficiency the Supersorbon process recovers such cheap solvents as gasoline at a cost of about 30 to 40 percent of the market value, while for higher priced solvents such as acetone the cost is only 6 to 8 percent of the value. The process is being successfully used to recover alcohol, ether, acetone, methyl, butyl

and amyl acetates and other solvents in the manufacture of explosives, dipped rubber goods, coated fabrics and the like. It is also used to recover dry cleaning solvent and solvents used in extracting oil seeds, coffee, tea, wool, bones and other products.

Digest from "Cross Section of the Supersorbon Process," by Ernest Schindel, *Chemische Apparatur* **27**, 257, 273, 1941. (Published in Germany.)

ALUMINOTHERMIC ALLOY PRODUCTION

When chromium-tungsten alloys are made by the aluminothermic method the product is alloyed with aluminum in proportions depending on the conditions. Coarse granular aluminum may introduce as much as 17 percent of aluminum into the alloy while finely powdered aluminum introduces only about 0.5 to 2 percent. Presumably much of the aluminum dust passes into the slag while the coarse particles tend to enter the alloy. In view of the high solubility of aluminum in solid chromium it might be expected that most of the alloys would be homogenous, but such is not the case. The aluminothermic method was used in making 28 alloys, the composition of which may be read off from the accompanying chart, where the alloys are numbered (1 to 28). Since the expected homogeneity was not obtained tests of tempering on homogeneity were carried out. Some of the alloys can be homogenized by tempering (heating at 1,000 deg. C.), but not those still containing free tungsten. Evidently a thin oxide film prevents reaction of these alloys in the solid state and they can be homogenized only by remelting.

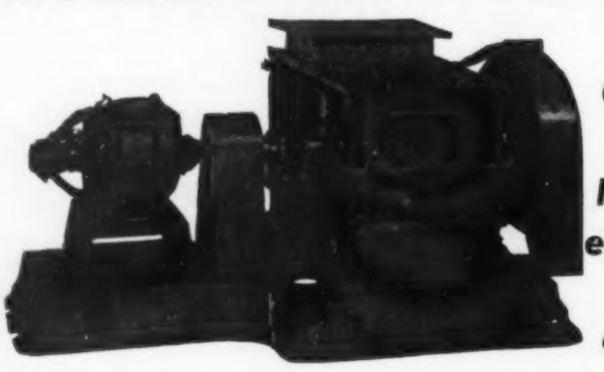


Chromium-tungsten-aluminum alloys

Digest from "Aluminothermic Production of Chromium-Tungsten Alloys," by Friedrich Weibke and Udo Freiherr Dundt. *Zeitschrift für Elektrochemie* **46**, 635, 1940. (Published in Germany.)

MASS DISTRIBUTION IN CENTRIFUGES

Some new machines are described which test centrifuge parts to ascertain the amount and location of compensating weight needed to maintain balance when the centrifuge is in operation. Balance is achieved through a system of springs and levers which serve to locate any weight eccentricity in the rotating part. In another machine for the same purpose there is an electromagnet which supplies the measured compensating force for centrifuge parts which are not in perfect balance. Still another tester utilizes another eccentric mass, rotating on a surface shaft, for the com-

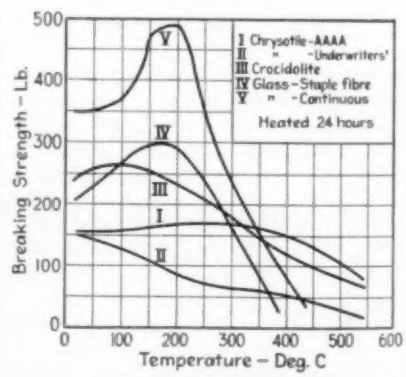


pensating force. All these devices serve well for single rigid centrifuge parts, but manual balancing is still necessary for centrifuge drums having numerous parts and operating at high speeds (6,000 to 10,000 r.p.m.). Weight eccentricities which are not apparent at low speeds become noticeable at high speeds. The mathematical principles of weight distribution are discussed.

Digest from "Weight Compensation in Rotating Centrifuge Parts," by W. Wilsmann, *Chemische Apparatur* **27**, 307, 321, 1941. (Published in Germany.)

HEAT RESISTANCE OF ASBESTOS

HEAT tests performed with Canadian asbestos (chrysotile) mill fiber showed that weight loss is nearly independent of time at temperatures above 700 deg. C. or below 500 deg. C., but between 500 and 700 deg. C. weight loss depends on time as well as on temperature. Prolonged heating at 490 deg. C. expelled about a fourth of the combined water, but when the temperature was held long at 510 deg. C. the dehydration was half completed. Complete dehydration is effected by long heating at about 580 deg. C. but weight loss does not become rapid until the temperature rises above 700 deg. C. With respect to breaking strength, there is first an increase as adsorbed moisture is expelled. Loss of strength does not begin until above 370 deg. C., as compared with a rapid loss at 250 deg. C. in glass fiber similarly woven. Hence, though glass fiber tape is initially stronger than chrysotile tape, it is greatly inferior in heat resistance. This is illustrated by the curves for



Effect of heat on breaking strengths of chrysotile, crocidolite and glass fiber tapes

chrysotile, crocidolite and glass fibers. Three grades of commercial asbestos-cotton cloth (79.5, 82 and 89 percent asbestos) were also tested. Strength loss begins in these as soon as heat is applied and is greater the lower the proportion of asbestos in the fabric. Thus, in 5 minutes at 300 deg. C. the 3 grades lost respectively 60, 35 and 25 percent of their initial strength.

Digest from "Thermal Studies on Asbestos. I. Effect of Temperature and Time of Heating on Weight Loss. II. Effect of Heat on Breaking Strength. III. Breaking Strength of Asbestos Cloth Containing Cotton," by D. Wolochow and W. H. White; D. Wolochow; D. Wolochow, *Canadian Journal of Research* **19B**, 49, 56, 65, 1941. (Published in Canada.)

VIBRATING MILLS

POWDERS can be ground to extreme fineness more efficiently in a vibrating mill than in a ball mill. This has been demonstrated by tests with marble dust in a rectangular mill charged about an inch deep with sand (grain size 0.8 to 1.2 mm.). The mill was operated at 150 cycles per second with an amplitude of 1.4 mm. The particle size of the powder can be quickly measured by a sedimentation method. The tests show that grinding should be effected at the lowest amplitude which will give sufficient shearing stress and pressure to disrupt the particles.

Digest from "Motion in Vibrating Mills," by D. Bachmann, *Zeitschrift des Vereines deutscher Ingenieure* **85**, 29, 1941. (Published in Germany.)

VAPOR BARRIERS IN WALLS

VAPOR barriers placed in building walls to prevent condensation of moisture are likely to have narrow cracks at edges and seams, whether the barrier is made of building paper or aluminum foil. Therefore, to know whether or not a wall is safe from condensation, it is necessary to know how much water vapor can diffuse through the cracks under service conditions. The problem cannot be simplified by assuming that diffusion is proportional to the area of the cracks because lines of flow are not straight and perpendicular to the cracks. Instead, vapor diffuses in from the sides and diffusion per unit area is much larger through a narrow slit than through a wide one. Diffusion tests with aluminum foil on plasterboard confirm this statement. Other tests were made with plaster on foil-backed plasterboard, for comparison. Equations which represent the lines of flow are derived from the Laplace equation. The curves for one equation are confocal ellipses while those for the other equation are confocal parabolas, all with the same focal distance in the equations.

Digest from "Diffusion of Water Vapor Through a Slit in an Impermeable Membrane," by J. D. Babbitt, *Canadian Journal of Research* **19A**, 42, 1941. (Published in Canada.)

WATER VAPOR IN PRODUCER GAS

IN HIGH temperature gasification of coal at very high gas velocities in narrow producers the entire reaction zone may be confined to a gas path which in the most extreme case corresponds only to the oxidation zone of ordinary producer operation. This is explained as due to an intermediate zone between the oxidation and reduction zones. In the intermediate zone most of the carbon monoxide is formed as oxidation diminishes and reduction gains in intensity. At the same time the steam reaction is extended to the reduction zone where it cannot proceed efficiently chiefly because the fuel layer here is being cooled by the gas blast. The fact that carbon monoxide formation is almost the sole reaction in the inter-

mediate zone is due to rapid combustion of hydrogen by atmospheric oxygen still present in the gas blast. This rapid reduction of carbon dioxide is aided by the high temperature in the intermediate zone, due to low heat loss in the narrowed reaction zone at high gas speeds and to initial combustion of oxygen to carbon dioxide.

Water may be introduced as liquid water (entrained droplets) or as steam in the gas blast, or as moisture already present in the coal. A water spray has no effect on the air input whereas steam permits use of less air and offers an opportunity to control temperature relations and zone boundaries to some extent.

Digest from "Formation of an Intermediate Zone Between the Oxidation and Reduction Zones in Gas Producers and the Behavior of Steam at High Gas Velocities," by J. Grvosdz, *Brennstoff-Chemie* 21, 269, 1940 (Published in Germany.)

PICKLING INHIBITORS

Search for pickling inhibitors to lower acid consumption and avoid metal losses in pickling baths has brought out a number of useful compounds which are effective in very small concentrations. Starch, though not highly potent, is a cheap inhibitor. Dibenzyl sulphoxide is among the recent potent synthetic inhibitors. Quinoline is moderately potent.

Because it is important to select a pickling inhibitor which will meet specified requirements at minimum cost, a rapid and inexpensive test method has been developed. Metal test pieces are pickled in a bath with no inhibitor and in a bath with a very small inhibitor concentration (e.g. 0.005 percent). Good inhibitors will show better than 30 percent protection under these conditions. Of 14 inhibitors tested by this method potency ranged from 12.3 percent protection with 0.125 percent starch up to 87.2 percent protection with 0.005 percent of a proprietary inhibitor.

Digest from "Testing and Evaluating Pickling Inhibitors," by W. Machu and O. Ungersböck, *Archiv für das Eisenhüttenwesen* 14, 263, 1940-41. (Published in Germany.)

HEAT EFFECTS IN COPPER WIRE

Because copper wire in overhead power transmission lines is subject to solar heat and the thermal effects of high voltage currents its stability to prolonged moderate heating is important. Tests with three brands of hard drawn wire from electrolytic oxygen-free copper showed much less softening than would be expected from reports in the literature. The test wires were drawn to 0.16-in. diameter for one series of tests and to 0.066-in. diameter for another series. After 18 months at 80 deg. C. some of the wires showed no appreciable softening and none showed more than a partial effect. Softening was estimated from tensile strength data.

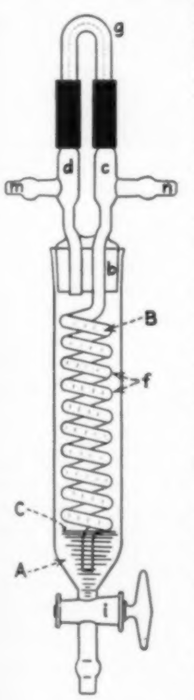
Because high conductivity copper is very sensitive to traces of impurities

these test results cannot be assumed to be generally applicable. It is therefore suggested that the percentage of hardening by cold working after the prolonged heating test offers a useful basis for comparison in testing copper wires for heat stability.

Digest from "Effect of Prolonged Heating at 80 deg. C. on Copper Wire," by E. Voce, *Journal of the Institute of Metals* 67, 1, 1941. (Published in England.)

LABORATORY FLOWMETER

To MEET the need for a flowmeter which would accurately measure very small amounts of gas flow a new glass instrument has been designed which will reliably and reproducibly measure rates of gas flow as low as 75 cc. per hr. Accuracy is favored by using a coiled graduated tube, so that a long scale occupies very little space (*B* in the diagram). This graduated tube is mounted by a standard ground glass connection in a glass cylinder *A* terminating in an outlet tube with stopcock *i*. A straight-arm capillary U-tube *g* is carried by the connecting ends *c* and *d*, which also carry the inlet and outlet side arms *m* and *n* for the gas to be measured. The instrument can be easily taken apart for cleaning. Its accuracy, since the scale reading in the coiled capillary can be made as large as desired for a given pressure drop in the U-tube, can be varied within wide limits. It depends only on the angle of ascent in the coiled capillary, the scale reading being greater the more nearly this ascending angle approaches the horizontal.



Digest from "Laboratory Flowmeter for Very Small Gas Volumes," by Paul Nashan, *Chemische Fabrick* 13, 471, 1940. (Published in Germany.)

PERMANENT STRENGTH OF MAGNESIUM

MANY strength and fatigue tests have been made with magnesium alloys in a study of permanent strength characteristics. Since notch effects are inevitable in many uses of light alloys the specimens were also tested for notch strength. Minute surface irregularities in cast, rolled, pickled and ground metal surfaces have sufficient notch effect to lower permanent strength somewhat as compared with polished metal. Permanent strength tests are reported on the basis of applying and

releasing the load 50,000,000 times. Tabulated data and curves show flexing resistance, notch strength, tensile strength, torsional strength and the effects of surface character and erosion on strength in various commercial magnesium alloys for aircraft and for other uses. Strength of welds was also studied. Some alloys are suitable for short welds while others give acceptable welds of any desired length. Ratio of weld strength to strength of the metal itself ranged from 0.6 to 0.9.

Digest from "Permanent Strength Properties of Magnesium Alloys," by W. Buchmann, *Zeitschrift des Vereines deutscher Ingenieure* **85**, 15, 1941. (Published in Germany.)

MELTING MAGNESIUM

Since magnesium and its alloys cannot be melted and worked by the methods commonly employed for other metals, the choice of a flux is vital to success. Carnallite has been used, because magnesium chloride dissolves magnesium oxide, but carnallite melts below 500 deg. C. and is too fluid for successful working of magnesium and its alloys, which are refined at about 740 deg. C.

A flux for magnesium must serve both to dissolve oxide and nitride and to cover the surface of a magnesium or alloy melt, thus preventing oxidation. As an improvement on carnallite, fluxes comprising magnesium chloride and magnesium fluoride are now employed. Calcium fluoride may be used instead of magnesium fluoride. These fluxes are efficient in removing oxide from magnesium or alloy melts and have sufficient viscosity for ready separation of flux from metal. But there is still the problem of flux inclusions, which are prevented only by constant vigilance. Research on chloride-free fluxes is needed.

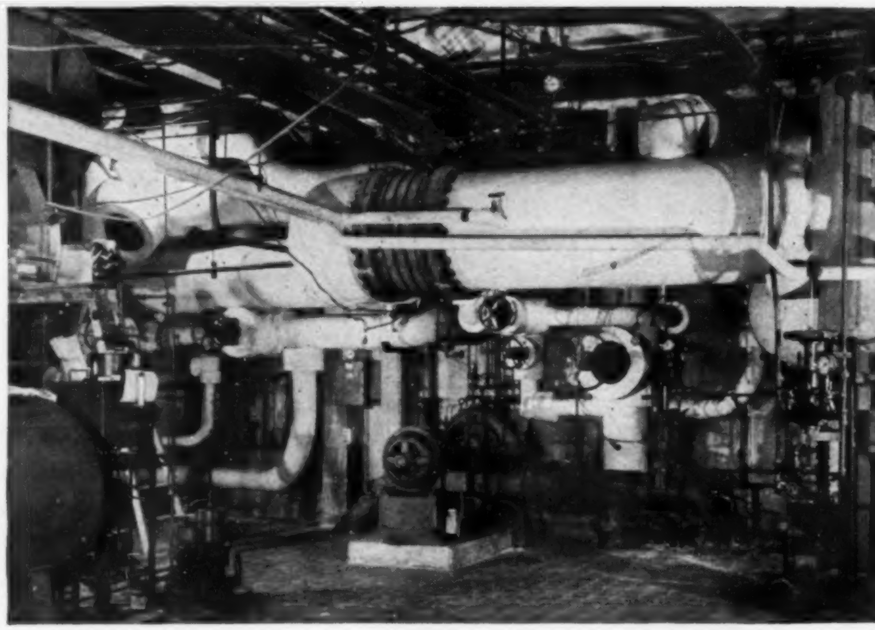
Digest from "Fluxes for Magnesium Melting," by J. P. Thomas, *Light Metals* **4**, 25, 1941. (Published in England.)

DENSIMETRY OF CORROSIVE GASES

In measuring the density of such hygroscopic or corrosive gases as hydrogen iodide or hydrogen fluoride the customary gas balance method and the gas column method both fail to meet requirements. A simple method has therefore been developed for measuring densities of such gases with an accuracy of about 1 percent. No greater precision is needed until correction factors are more accurately known than at present. A simple xylene manometer is employed, but its readings are made accurate to 0.01 mm. by a microscope illuminated with a parallel beam of light. Because of this manometric precision very short gas columns may be used. Ordinarily the reference gas is air. The manometer is protected from the gas by a buffer chamber.

Digest from "Densimetry of Corrosive Gases," by H. von Wartenberg, *Zeitschrift für Elektrochemie* **47**, 92, 1941. (Published in Germany.)

DOES YOUR INSULATION INVESTMENT PAY A *FULL* RETURN?



On Furnaces where insulation is required to resist temperatures up to 1900° F., J-M Superex is widely recognized as the most efficient block insulation available today. Hundreds of installations under all types of operating conditions prove its long life and low maintenance.

For Temperatures Up To 600° F., you save by using J-M 85% Magnesia. For years the standard material for insulating power-plant equipment and steam lines, it combines light weight with permanently high insulating efficiency.

HOW much money you spend on fuel depends to a large extent on the answers to these two questions:

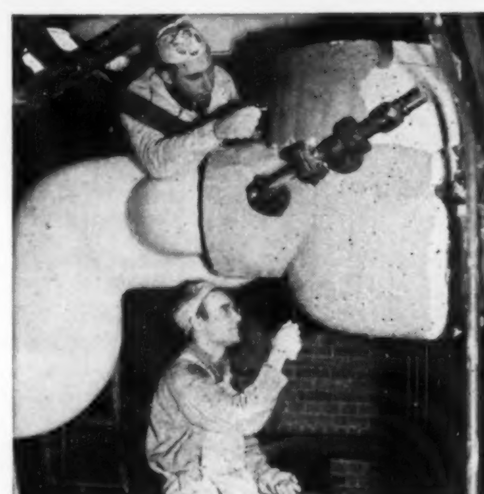
Are you using the *correct insulating materials?*

Are they applied in the *correct thicknesses?*

To assure every saving possible with insulation, it will pay you to call in a J-M Insulation Engineer. Let him study your requirements . . . his specialized technical training and experience will help you trace down and correct sources of heat waste that may otherwise go unnoticed.

From the complete line of J-M Insulations, he can recommend exactly the *material* you need for greatest efficiency . . . exactly the *thickness* you need for maximum returns.

For full details on this helpful service and facts about the complete line of J-M Industrial Insulations, write to Johns-Manville, 22 East 40th Street, New York, N. Y.



On Superheated Steam Lines, J-M Superex Combination Insulation effectively guards against costly heat waste. Built up of an inner layer of Superex and an outer layer of 85% Magnesia, this combination assures maximum heat resistance and insulating efficiency.

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Superex . . . 85% Magnesia . . . JM-20 Brick . . . Sil-O-Cel C-22 Brick . . . Sil-O-Cel Natural Brick . . . J-M No. 500 Cement . . . Sil-O-Cel C-3 Concrete . . . Marinite

New Titles, Editions and Authors

Chem & Met BOOKSHELF

GASES AND HISTORY

CHEMICAL WARFARE. By *Curt Wachtel*. Published by Chemical Publishing Co., Brooklyn, N. Y. 312 pages. Price $4.

FROM a historical standpoint, Dr. Wachtel's book is an important contribution to the literature of gas warfare. He organized the pharmacological section of Kaiser Wilhelm Institute and was actively associated with Fritz Haber during the first World War. His reminiscences and stories of this great engineer, his associates and their research, studies and experiences make fascinating reading. These are interspersed throughout the text. Particularly illuminating are the discussions of economic factors which weighed for or against the use by Germany of various toxic gases.

There are 12 chapters in the book which discuss aspects of gas warfare including The Idea of Chemical Warfare, How to Develop a New Gas, Evaluation of Gases, Toxicity Figures and Standards, and Treatment and Protection. Separate chapters are also devoted to arsenic and sulphur compounds, irritant poisons, the cyanogen group and explosive gases.

In several places unfortunate typographical errors are in evidence. In themselves these are relatively unimportant being merely evidence of haste to make the book available to the public. They do, however, tend to create a questioning attitude on the part of the reader.

Statistics given for World War mortalities indicate gas is the most humane weapon ever used. Nevertheless, we are discouraged by the statement, "Mustard gas is still a highly valuable war gas and will certainly be used in the field as soon as the military circumstances are considered favorable."

MEN AND VOLTS. By *John Winthrop Hammond*. Published by A. B. Lippincott Co., New York, N. Y. 436 pages. Price $2.50.

Reviewed by *M. H. Hamilton*

THIS was intended to be merely the story of the origin and development of the General Electric Co. As the title would suggest, however, because of the wide ramifications of the subject, the material transcends the confines of an industrial biography and becomes in a sense "the epic of electricity" and of the men who gave it to the world at large.

The original manuscript, we are told in the Preface, was written by John Winthrop Hammond who, after fifteen years of writing and research, had carried his history only up to 1922. The book as it now appears was edited after Mr. Hammond's death by Arthur Pound, who not only condensed the original 300,000 words to an approximate 120,000, but also added an entirely inadequate Epilogue which covers the remaining eighteen years and brings the book up to date.

As an historical treatise, this work indicates tireless and meticulous research. Because of the tremendous scope of the material involved, one might easily become lost in a welter of facts and names. Instead, however, by virtue of the structural plan of the book, even the most exoteric can follow the pattern with ease.

The early chapters deal largely with the creativity of the four pioneers who made electricity at once a science and an industry. These men were Thomas Edison, the inventor of the incandescent light, Elihu Thomson, Charles F. Brush, and James J. Wood, each of whom fashioned an electric dynamo and an arc light of his own. Parts II, III, and IV cover the introduction of commercial lighting throughout the United States and the entry of electricity into the field of transportation. The remaining chapters are concerned largely with the formation and expansion of the General Electric Co. and the men who comprised it from its inception to the present.

Technically, this volume offers a storehouse of information, some of which may be unintelligible to the layman. A profusion of illustrations mitigate this situation to some extent, and should prove of interest to the electrical engineer.

From a literary standpoint the book leaves much to be desired, although the manner in which the author has attached personal and often humorous anecdotes to each of the individuals who figure in his story is most commendable. Interesting also are the frequently interpolated contemporary newspaper accounts of early electrical inventions which were received by the public with both awe and misgiving.

The magnitude of electricity cannot be over-emphasized, nor its potentialities minimized. History may consider these first sixty years as the mere infancy of the industry. Meanwhile, this book will serve as a valuable record of the deeds of men who in less than a century revolutionized the civilized world.

PATENT FUNDAMENTALS. By *Leon H. Amdur*. Published by Chemical Publishing Co., Brooklyn, N. Y. 305 pages. Price $4.

ELEMENTARY in its treatment of a complex subject, Mr. Amdur's latest book offers the interested layman an opportunity of acquiring much general information about patents. Anyone wishing a better understanding of the subject and the procedure for obtaining a patent will find this book a comprehensible guide. Among the subjects discussed are types of invention, inventions as defined by patent claims, the nature of a patent, how patents are classified, preparation and prosecution of applications, plant patents, and dealings in patents.

As a source of information on the vast subject of chemical patents the book leaves something to be desired. Abbreviation of some of the material on plant patents would have permitted space for some attention to chemical patents — a subject which as was pointed out in these columns three months ago, provides more than half of all patent litigation.

ANOTHER FOR THE RECORD

WERKSTOFFE, MIRACLES OF GERMAN CHEMISTRY. By *Dr. Karl Dorn* with preface by *Dr. Matthias Schmitz*. Published by German Library of Information, New York, N. Y. 30 pages.

Reviewed by *S. D. Kirkpatrick*

WIDELY circulated within the past few weeks to teachers, librarians and public officials, this attractive little book is designed to impress us with Germany's leading place in the world of science and industry. It is part of a more or less subtle series of propaganda publications on "The Economic Strength of the New Germany." Few chemical readers will be fooled by its fallacious statements but it is irritating to find them being accepted by otherwise well informed laymen.

After explaining that *Werkstoffe* are the working materials of industry and are not to be confused with inferior *ersatz* or substitutes. The preface presents these disarming statements: "Where Germany has led, the fact is reported calmly and proved by statistics. Where other countries have led, their victory is conceded. Nothing essential is omitted." "Says who?" and "Oh, yeah!" are our most charitable comments.

On page 5 we are told "the first spun-fibre (spinnfaser) made from coal and limestone" is "Pe-ce-fibre, first marketed early in 1939, represents a new departure" in which "German industry has been successful in this most important undertaking after trying for more than 25 years to find a method by which coal and limestone could be employed as basic materials." All ref-

erences to Nylon and Vinyon are omitted, representing, presumably, "nothing essential" in this connection.

On pages 8 and 9 we read "the oldest Werkstoffe based on the synthetic resins, Bakelite, originated in a German factory. Bakelite is a purely German material produced from byproducts of the distillation of hard coal and wood, phenol and formaldehyde." If that is true this little book is purely German material produced from the byproducts of the imagination of synthetic propagandists and should be preserved in phenol and formaldehyde in Dr. Baekeland's museum of chemical curios.

HOW TO TEACH A JOB. By *R. D. Bundy*. Published by National Foremen's Institute, Inc., Deep River, Conn. 63 pages. Price $1.

NATIONAL defense is making demands on many shops for tremendously increased production. Selective service is removing workers and apprentices from these selfsame shops. The problem of employee training for semi-skilled jobs is therefore doubly acute. In the past, the duty of breaking in a new man usually fell to a foreman whose success at teaching often left something to be desired. New recruits, however, can be turning out work that will pass inspection after a minimum of instruction — if the instruction is properly handled.

Four steps in teaching a job are given by Mr. Bundy. They are: 1. Getting an idea across; 2. Presentation; 3. Application—the student actually begins to produce; 4. Testing or inspection. To help with presentation, the last two chapters of this little book are devoted to lesson planning analysis.

No reference is made to instruction for the jobs in a chemical plant, but the ideas presented may readily be translated from shop to plant pedagogy.

MANUAL OF A.S.T.M. STANDARDS ON REFRACTORY MATERIALS. Published by American Society for Testing Materials, Philadelphia, Pa. 174 pages. Price $1.50 (board cover). $1.75 (cloth).

PRESENTING in their latest approved form all of the A.S.T.M. Specifications, Tests and Definitions covering refractory materials, this edition supersedes the one published four years ago.

There are five specifications providing quality requirements for refractories for various services: boiler service, incinerators, malleable iron furnaces, and also covering ground fire clay and there are two classifications covering fire clay refractories and insulating brick and insulating firebrick. The 15 standardized testing procedures, comprising a major portion of the publication, cover such matters as pyrometric cone equivalent, permanent linear change, load tests, cold crushing strength, warpage, porosity and methods of chemical analysis. Also given is a recommended procedure for calculating losses through furnace walls and standardized terms covering refractories and symbols for heat transmission.

GOVERNMENT PUBLICATIONS

Documents are available at prices indicated from Superintendent of Documents, Government Printing Office, Washington, D. C. Send cash or money order; stamps and personal checks not accepted. When no price is indicated, pamphlet is free and should be ordered from bureau responsible for its issue.

Explosives or Other Dangerous Articles on Board Vessels. Regulations prescribed by the Secretary of Commerce. Bureau of Marine Inspection and Navigation, unnumbered document; $1.00.

Characteristics of Fuel Pitches and their Explosibility in Pulverized Form, by Irving Hartmann and others. U. S. Bureau of Mines, Technical Paper 617; 10 cents.

Thermodynamic Properties of Gypsum and its Dehydration Products, by K. K. Kelley and others. Bureau of Mines, Technical Paper 625; 10 cents.

Hydrogenation and Liquefaction of Coal. Part I.—Review of literature, description of experimental plant, and liquid-phase assays of some typical bituminous subbituminous, and lignitic coals, by H. H. Storch and others. U. S. Bureau of Mines, Technical Paper 622; 20 cents.

Production of Explosives in the United States During the Calendar Year 1939, by W. W. Adams and others. U. S. Bureau o.' Mines, Technical Paper 627; 5 cents.

Reconnaissance of Gold-Mining Districts in the Black Hills, S. Dakota, by Paul T. Allsman. U. S. Bureau of Mines, Bulletin 427; 20 cents.

Increasing the Concentration of Sulfur Dioxide in the Effluent Gases from Dwight-Lloyd Sintering Machines Treating Lead Products, by Virgil Miller and others. U. S. Bureau of Mines, Technical Paper 624; 10 cents.

Survey of Fuel Consumption at Refineries in 1939, by G. R. Hopkins. U. S. Bureau of Mines, Report of Investigations 3554; mimeographed.

Measuring Particle-Size Distribution and Colloid Content of Oil-Well Drilling Fluids, by George L. Gates. U. S. Bureau of Mines, Report of Investigations 3549; mimeographed.

Iceland Spar and Optical Fluorite, by H. Herbert Hughes. U. S. Bureau of Mines, Information Circular 6468R; mimeographed.

Froth Flotation and Agglomerate Tabling of Micas, by James E. Norman and R. G. O'Meara. U. S. Bureau of Mines. Report of Investigations 3558; mimeographed.

Alunite Resources of the United States, by J. R. Thoenen. U. S. Bureau of Mines, Report of Investigations 3561; mimeographed.

Pulmonary Diseases in the Mining Industry, by R. R. Sayers. U. S. Bureau of Mines, Information Circular 7146; mimeographed.

Annual Report of the Metallurgical Division, Fiscal Year 1940, by R. S. Dean. U. S. Bureau of Mines, Report of Investigations 3547; mimeographed.

Utilization of Manganese in the Steel Industry, by B. A. Rogers. U. S. Bureau of Mines Information Circular 7162; mimeographed.

Influence of Expanding Construction on Shipments of Building Materials. U. S. Bureau of Mines, Information Circular 7157; mimeographed.

Bluing of Iron and Steel. National Bureau of Standards, Letter Circular 630, February 1, 1941; mimeographed.

Paper, Basic Sheet Sizes. National Bureau of Standards, Simplified Practice Recommendation R22-40; 5 cents.

Economic Review of Foreign Countries, 1939 and Early 1940. Bureau of Foreign and Domestic Commerce, Economic Series No. 9; 35 cents.

Splint Coals of the Appalachian Region: Their Occurrence, Petrography, and Comparison of Chemical and Physical Properties with Associated Bright Coals, by G. C. Sprunk et al. U. S. Bureau of Mines, Technical Paper 615; 10 cents.

Effect of Particle Size on the Rate of Oxidation of Anthracite, by G. S. Scott and G. W. Jones. U. S. Bureau of Mines, Report of Investigations 3546; mimeographed.

Directory of the Bureau of Entomology and Plant Quarantine 1940. U. S. Department of Agriculture, Miscellaneous Publication No. 220, Revised; 15 cents.

Summary of Foreign Trade of the United States, Calendar Year 1939, by Grace A. Witherow. Bureau of Foreign and Domestic Commerce, Trade Promotion Series No. 215; 10 cents.

Foreign Long-Term Investments in the United States, 1937-39, by Paul D. Dickens. Bureau of Foreign and Domestic Commerce, Economic Series No. 11; 15 cents.

Role of Clay and Other Minerals in Oil-Well Drilling Fluids, by A. George Stern. U. S. Bureau of Mines, Report of Investigations 3556; mimeographed.

Summary of Records of Surface Waters of Washington, 1919-35. U. S. Geological Survey, Water-Supply Paper 870; 65 cents.

Chromite Deposits in the Seiad Quadrangle, Siskiyou County, California, by G. A. Rynearson and C. T. Smith. U. S. Geological Survey, Bulletin 922-J; 30 cents.

Chromite Deposits in the Sourdough Area, Curry County, and the Briggs Creek Area, Josephine County, Oregon, by F. G. Wells, L. R. Page, and H. L. James. U. S. Geological Survey, Bulletin 922-P; 30 cents.

Chromite Deposits of the Pilliken Area, Eldorado County, California, by F. G. Wells, L. R. Page, and H. L. James. U. S. Geological Survey, Bulletin 922-0; 35 cents.

Gas Treatment for the Control of Blue Mold Disease of Tobacco, by Edward E. Clayton et al. U. S. Department of Agriculture, Leaflet No. 209; 5 cents.

Forest Products Statistics of Central and Prairie States, by R. V. Reynolds and A. H. Pierson. U. S. Department of Agriculture, Statistical Bulletin No. 73; 15 cents.

The Corrosive Effect of Chlorine and Lye Solutions on Metals Used in Dairy Equipment, by H. S. Haller and others. U. S. Department of Agriculture, Technical Bulletin No. 756; 5 cents.

Harvesting Pyrethrum, by A. F. Sievers and others. U. S. Department of Agriculture, Circular No. 581; 5 cents.

Anatomical Structure of the Cottonseed Coat as Related to Problems of Germination, by D. M. Simpson and others. U. S. Department of Agriculture, Technical Bulletin No. 734; 5 cents.

Ramie Fiber Production, by Brittain B. Robinson. U. S. Department of Agriculture Circular No. 585; 5 cents.

Composition of American Gum Turpentines Exclusive of the Pinenes. U. S. Department of Agriculture, Technical Bulletin 749; 5 cents.

Turpentine Still Buildings and Equipment. U. S. Department of Agriculture, Miscellaneous Publication 387M; 15 cents.

Water Levels and Artesian Pressure in Observation Wells in the U. S., 1939, by O. E. Meinzer and others. U. S. Geological Survey, Water-Supply Paper 886; $1.00.

Quicksilver Deposits of the Mayacmas and Sulphur Bank Districts, California, by C. P. Ross. U. S. Geological Survey Bulletin 922-L; 45 cents.

Tungsten Deposits in the Tungsten Hills, Inyo County, California, by Dwight M. Lemmon. U. S. Geological Survey, Bulletin 922-Q; 20 cents.

Tungsten Deposits of the Benton Range, Mono County, California, by Dwight M. Lemmon. U. S. Geological Survey, Bulletin 922-S; **30 cents.**

Chromite Deposits of the Eastern Part of the Stillwater Complex, Stillwater County, Montana, by J. W. Peoples and A. L. Howland. U. S. Geological Survey Bulletin 922-N; **40 cents.**

The Goodnews Platinum Deposits, Alaska, by J. B. Mertie, Jr. U. S. Geological Survey, Bulletin 918; 50 cents.

Minerals Census Reports. Preliminary reports by commodity are now available for most of the items covered in the Census of Mineral Industries, 1940 (operations of 1939). Data relate to general and management features of

the industry rather than to technical detail. These are available on request for individual commodities at the Bureau of the Census.

Power Equipment Report. Census of Manufactures, 1939, preliminary report on prime movers in manufacturing plants. Bureau of the Census; mimeographed.

Miscellaneous Crude Drugs, Analysis of Imports through New York in 1939. U. S. Tariff Commission, unnumbered mimeographed document, April, 1941.

Patents and Free Enterprise, by Walton Hamilton. Temporary National Economic Committee, Monograph No. 31; 25 cents.

Economic Reports. Several of the Temporary National Economic Committee Monographs give broad statistical interpretation of the present status or trends of important industries. Among these are the following: Monograph No. 21, Competition and Monopoly in American Industry, by Clair Wilcox and others, 40 cents; Monograph No. 27, The Structure of Industry, by Walter F. Crowder and Don Humphreys, $1.00.

Classification, Processing, and Inspection of Leather and Leather Equipment. War Department, Technical Manual 10-226; 10 cents.

Military Chemistry and Chemical Agents. War Department, Technical Manual 3-215; 25 cents.

RECENT BOOKS and PAMPHLETS

Handbook of Welded Steel Tubing. Published by Formed Steel Tube Institute, Cleveland, Ohio. 86 pages. Price $1. A spiral-bound, pocket-sized handbook, giving advantages and manufacturing methods of welded steel tubing. Includes numerous tables of dimensions and properties as well as specifications, recommendations and definitions.

A Survey of the Science of Heat Transmission. By Dr. Max Jakob. Published by Purdue University, Lafayette, Ind. 55 pages. Price 25 cents. Presents three lectures which were given by Dr. Jakob at Purdue. The topics were: Fundamental Laws of Heat Transmission, Decisive Properties of Matter, Typical Methods (of solving equations in order to make them suitable for practical use).

The Chemical Age Yearbook, 1941. Published by Benn Bros., Ltd., 154 Fleet St., London, E. C. 4. 116 pages. In its nineteenth year the yearbook is somewhat thinner than usual because of the omission of tables of chemical constants, logarithms, etc. Manufacturers of equipment and chemicals are, as usual, well represented. Lists of organizations, standards and "Who's Who" have been retained. A section on "Control Orders" is also included.

China Tung Oil and its Future. By C. C. Chang. Leaflet No. 8, published by the China Vegetable Oil Corp., Hong Kong, China. 129 pages. Copies available from Wilbur-Ellis Co., New York. Price 50 cents. An exposition on the economic importance of tung oil for china, primarily directed to the price aspect. Discusses the China tung oil industry; trade returns of exports; inherent weaknesses of Chinese production and distribution; threat from foreign plantations; interchangeability and drying oils; compatability and synthetic drying oils; and the price factor.

Eighth Annual Report of the Engineers' Council for Professional Development. Published by E. C. P. D., New York, N. Y. 55 pages. Contains a number of committee reports in addition to lists of participating bodies, officers, committee personnel, etc. The report on engineering schools includes a list of accredited undergraduate curricula in the United States.

Priorities and Defense. Available from Division of Information, Office of Emergency Management, Washington, D. C. A handbook on the operation of the priorities system. Includes a general statement on the theory and administration of the priorities system, a question and answer section, a copy of the Priorities Critical List, the official instructions on priorities to Supply Arms and Services of the Army and Bureaus and Offices of the Navy Department, and reproductions of preference rating forms.

MANUFACTURERS' LATEST PUBLICATIONS

Publications listed here are available from the manufacturers themselves, without cost unless a price is specifically mentioned. To limit the circulation of their literature to responsible engineers, production men and industrial executives, manufacturers usually specify that requests be made on business letterhead.

Alloys. The Enthone Co., 442 Elm St., New Haven, Conn.—Folder on this company's "Ebonol Z" process for blackening zinc and its alloys by immersion, with brief description of equipment, solution, blackening technique, limitations and uses.

Blowers. Allis-Chalmers Mfg. Co., Milwaukee, Wis.—Bulletin B6104—32-page booklet on this company's multistage blowers of the turbo type, describing and illustrating installations, methods of operation, design, and construction features of blowers for use in blast furnaces, converters, sewage disposal plants, etc.

Chemicals. American Cyanamid & Chemical Corp., 30 Rockefeller Plaza, New York—Leaflet 581—24-page booklet on this company's sodium tetraphosphate or "Quadrafos", giving formula and properties, solubility and pH data, industrial applications in textile and other industries, packages and methods of laboratory testing. Certain properties are illustrated by charts. Also Leaflet 501 revised, listing this company's chemical and allied products alphabetically and by industrial uses, with detailed information on uses of certain chemicals.

Chemicals. Eastman Kodak Co., Chemical Sales Division, Rochester, N. Y.—List No. 32—1941 catalog, consisting of 140 pages, listing prices of this company's organic chemicals, together with new items listed for the first time. Catalog contains more than 3,400 different chemicals of research, reagent, and other grades.

Chemicals. The Mathieson Alkali Works, Inc., 60 E. 42nd St., New York—16-page booklet covering in detail this company's anhydrous ammonia, including chemical and physical properties, pressure and temperature relation curves, density and solubility tables, containers, handling, piping and valves, and physiological and first-aid measures.

Clays. Ferro Enamel Corp., Cleveland, Ohio—A brochure announcing this company's controlled consistency clay used in processing porcelain enameled metal products. Development and advantages are very briefly described.

Construction. The Atlas Lumnite Cement Co., 135 E. 42nd St., New York—18-page reprint on structural design of factory concrete, with valuable information in the form of charts and sketches, describing methods of building industrial furnace and kilns with reinforced concrete.

Construction. Macwhyte Co., Kenosha, Wis.—Eight-page pamphlet describing and illustrating in detail safe sling practice in attaching loads to cranes, lifting beams, and similar devices.

Control. Automatic Switch Co., 41 E. 11th St., New York—76-page catalog in notebook form on this company's solenoid-operated valves and other automatic controlling devices for air, gas, steam and liquids. This catalog, which is the 1941 edition, gives valuable and detailed information on general specifications, controls and connections, installation and maintenance, list prices and specifications.

Controls. The Foxboro Co., Foxboro, Mass.—Bulletin 241—8-page bulletin on this company's time and sequence systems for automatic process operation with explanation of typical installations, accompanied by photographs and drawings, and a brief discussion of advantages.

Control. Industrial Instruments, Inc., 156 Culver Ave., Jersey City, N. J.—two-page sheet describing briefly principles and uses of this company's Solu-Bridge controller for automatic solution control.

Control. Moore Products Co., 3629 N. Lawrence St., Philadelphia, Pa.—One-page sheet for notebook filing on this company's new valve positioner for diaphragm-operated valves, which describes briefly principles and construction.

Controls. Reeves Pulley Co., Columbus, Ind.—6-page folder on hydraulic automatic control to be used in connection with company's variable speed transmission. Illustrated by photographs and drawings.

Controls. Westinghouse Electric & Mfg. Co., Editorial Service, East Pittsburgh, Pa. — Catalog 30-000 — 64-pages, 1941 revision of catalog on selection of electrical equipment for motor, lighting or feeder circuits, including subjects such as safety switches, multi-breakers, panel boards, motor controls and motors, with price changes and application data.

Electrical Equipment. Electric Machinery Mfg. Co., Minneapolis, Minn.—12-page pamphlet on this company's magnetic variable-speed drives, presenting principles, characteristics, advantages, and constructional forms in graph, table, drawing and text forms.

Electrical Equipment. Ideal Commutator Dresser Co., Sycamore, Ill.—Form EW1140—Folder describing very briefly this company's electric arc welder, with specifications and advantages.

Enamels. The Porcelain Enamel & Mfg. Co., Baltimore, Md.—4-page folder briefly listing types and uses of this company's porcelain enamels.

Engines. Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago, Ill.—12-page booklet illustrating by drawings and photographs features of this company's diesel engines, with particular reference to modernizing by change-over parts.

Equipment. American Machine & Metals, Inc., De Bothezat Ventilating Equipment Division, East Moline, Ill.—Bulletin No. 641—eight pages on this company's air-jet cooler for reducing fatigue of workmen in foundries, forge shops, steel mills, etc. Includes detailed information on performance, dimensions and engineering drawings.

Equipment. Heat Transfer Products, Inc., 90 West St., New York—Folder describing very briefly this company's self-scaling evaporators, with detailed drawings showing design and practical construction. Also Bulletin No. 101A, describing the company's shell and tube heat exchangers, with brief descriptions and list of applications.

Equipment. Hevi-Duty Electric Co., Milwaukee, Wis.—Bulletin HD341—8-page bulletin dealing with this company's multi-range convection furnaces, with photographs showing installations, general discussion of construction and parts, and a chart of specifications.

Equipment. Hirsch Machinery Co., 429-435 Frelinghuysen Ave., Newark, N. J.—Folder listing this company's used chemical and industrial machinery, such as kettles, air compressors, blowers and fans, boilers and engines, drying equipment, filters, agitators, pumps, etc.

Equipment. Homestead Valve Mfg. Co., Coraopolis, Pa.—Bulletin 17A8—2-page folder describing very briefly this company's high pressure steam cleaners for motors, machinery, floors, etc.

Equipment. Lamson Corp., Syracuse, N. Y.—Form No. 740—8 pages of illustrated and descriptive material on this company's conveyors for breweries and other industrial purposes.

Equipment. Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill.—Bulletin No. 1882—8-page pamphlet covering this company's line of welded steel base plates for adjusting pillow-blocks and

common flat boxes for shaft alignment, accompanied by price lists and engineering data.

Equipment. Newark Wire Cloth Co., 351 Verona Ave., Newark, N. J.—Small folder on this company's testing sieves and testing sieve shaker, with brief descriptions and chart of specifications and prices for testing sieves.

Equipment. The Manhattan Rubber Mfg. Div., Raybestos-Manhattan, Inc., Passaic, N. J.—4th edition of the Condor V-belt engineering data book, covering standard drive, sheave factors and other data for designing drives, belt comparison tables, illustrations, and other general information of interest to machine designers, engineers, jobbers and instructors.

Equipment. Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill.—Folder A640—2-page folder briefly describing and illustrating this company's rubber-tread return idlers for belt conveyors, including dimensions and price list.

Equipment. Roots-Connersville Blower Corp., Connersville, Ind.—Bulletin G70—8-page folder on this company's blowers, exhausters and boosters, liquid and vacuum pumps, gas generators, and displacement meters, each of which is illustrated by photograph and described.

Equipment. T. Shriver & Co., 808-864 Hamilton St., Harrison, N. J.—Bulletin No. 113—4-page pamphlet on Shriver filter presses for vegetable, animal and fish oils, with brief discussion of uses, construction features, and filtering capacity.

Filters. Eimco Corporation, Salt Lake City, Utah—Bulletin 404—48 pages of information on this company's continuous vacuum filters for metallurgical, chemical processing, food products, paper, pulp, sewage disposal and other uses giving detailed information on principles of operation, sizes and dimensions, accessory equipment, drawings of elevation arrangement, and industrial applications in a large number of different industries.

Flotation. Denver Equipment Co., 1400 17th St., Denver, Colo.—Bulletin F11B—18-page catalog describing equipment and installations for flotation of various materials, including detailed engineering information on capacities, flowsheets and construction of cells.

Heat Lamps. Birdseye Division, Wabash Appliance Corp., 335 Carroll St., Brooklyn, N. Y.—Bulletin 121B—4-page pamphlet on this company's infra-red heat lamps, which describes briefly operating advantages of the lamp, general principles, with photographs illustrating uses in industry for baking, drying, and dehydrating.

Instruments. Adam Hilger, Ltd., 98 St. Pancras Way, Camden Road, London, N. W. 1—Publication No. S. B. 294—4-page pamphlet on this company's non-recording x-ray microphotometer, describing construction, accessories and prices. Also Publication No. S. B. 295, with 4 pages on the Spekker photoelectric fluorimeter, with brief description of application and advantages, including prices.

Instruments. Toledo Scale Co., Toledo, Ohio—Folder illustrating and describing briefly this company's dial indicator and beam indicator motor truck scales. Photographs illustrate typical installations.

Instruments. Westinghouse Electric & Mfg. Co., Editorial Service, East Pittsburgh, Pa.—Catalog Section 43-414—12-page bulletin on this company's improved ammeters and voltmeters for general use. Also includes switchboard, portable, wall and socket type, including information on application, operation, construction details, list prices and mounting details.

Laboratory Equipment. Alberene Stone Corp. of Va., 419 Fourth Ave., New York—12-page booklet, describing this company's laboratory material for table tops, sinks, wall-tables, drainboards and fume hoods, with photographs of typical installations, detailed drawings of construction, and general specifications.

Lubrication. Trabon Engineering Corp., 1814 E. 40th St., Cleveland, Ohio—4-page bulletin on this company's sin-

gle pipe non-reversing centralized lubrication distributor, illustrating and describing briefly principles and applications.

Metallurgy. Metallizing Engineering Co., Inc., 21-07 41st Ave., Long Island City, N. Y.—Bulletin No. 42—16 pages on this company's "Metco" metallizing equipment and metallizing process for protecting metals against corrosion, chemical attack, and wear. Also includes information on various types of metal spraying guns.

Mining. Independent Pneumatic Tool Co., 600 W. Jackson Blvd., Chicago, Ill.—Catalog No. 42—Catalog describing this company's line of mining and contractors' air-powered tools, giving descriptions and specifications of rock drills, paving breakers, clay and trench diggers, sump pumps, etc. Specific applications are illustrated, and each tool has detailed specifications and description data.

Packaging. Stokes & Smith Co., 4943 Summerdale Ave., Philadelphia, Pa.—Form 4943—Folder illustrating and describing briefly this company's packaging machinery and its application in the food and allied industries.

Pumps. DeLaval Steam Turbine Co., Trenton, N. J.—4-page reprint on operation of centrifugal boiler-feed pumps with engineering data in graph, drawing, and text form.

Pumps. Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago, Ill.—Bulletin 5410 FF—14-page booklet describing this company's new submerged suspended sump and bilge pumps, with illustrations of typical installations, details of construction, principal dimensions, and extensive pump selection tables.

Pumps. Lawrence Machine & Pump Corp., 371 Market St., Lawrence, Mass.—Bulletin 207-2—4-page pamphlet describing this company's slurry and sludge pumps, with photographs illustrating the different types, cross-section drawings, specifications of various parts, and data on sizes and capacities.

Synthetic Rubber. The Hydrocarbon Chemical & Rubber Co., 335 S. Main St., Akron, Ohio—8-page bulletin written in non-technical language describes and illustrates the properties, handling, and physical characteristics of this company's "Hycar" type of synthetic rubber.

Valves. Hancock Valve Div., Manning, Maxwell & Moore, Inc., Bridgeport, Conn.—Bulletin 4-4500-D—8 illustrated pages with charts describing the "500 Brinell" bronze valves of this company, including price lists, weight and dimensions, working pressure ratings, and other data.

Valves. Reading-Pratt & Cady Div., American Chain & Cable Co., 929 Connecticut Ave., Bridgeport, Conn.—Catalog No. 332—catalog giving specifications and applications of cast steel valves and fittings, with illustrations of cross sections and individual parts, typical chemical and physical properties of the metals, design features of the various types, with dimensional drawings and specifications and engineering data on selection and installation.

Valves. Henry Vogt Machine Co., 10th and Ormsby Sts., Louisville, Ky.—Catalog P8—Catalog on this company's drop forged steel valves, fittings, and flanges.

Valves. Homestead Valve Mfg. Co., Inc., Coraopolis, Pa.—a 4-page folder on this company's valves, with illustrations of installations, brief descriptions of uses on ships and in defense industries.

Water Treatment. F. J. Stokes Machine Co., Tabor Road, Olney P. O., Philadelphia, Pa. — Catalog 417—24 pages on this company's water stills of both laboratory and industrial types, with photographs of actual installations and detail information on operating principles, advantages, design and construction, and specification and shipping data.

Welding. The Esterline-Angus Co., Inc., Indianapolis, Ind.—Bulletin No. 341—4 pages on arc welding, with emphasis on cost reduction and control by use of this company's graphic time recorders. Gives discussion of advantages, details of system, and results obtained.

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Chem & Met ECONOMICS and MARKETS

CONSUMING INDUSTRIES CONTINUE TO TAKE ON STOCKS OF CHEMICALS AT STEADY RATE

Most of the important consuming industries are maintaining a steady rate of manufacturing operations and deliveries of chemicals and other raw materials reflect this condition. On April 24, the new powder plant at Charlestown, Ind. started operations on two of its six powder lines. Two more lines will be in production very soon and the last two probably by late summer. Hence the normal consuming lines are being increased by the completion of defense plants and additional outlets for chemicals are being opened up. The number of chemical items which are classified as scarce is growing and it is evident total consumption —including home requirements and export demands—would be larger if supplies were more plentiful. Another factor which is receiving some consideration is the possible scarcity which may develop later on in the number of freight cars which will be available for moving goods. The lack of sufficient vessels for our import and export trade has been given prominence but there also appears to be some complications in our coastwise shipments. For instance, there are reports that ships have not been available for moving phosphate rock to acidulating plants. The defense program counts on the fertilizer industry to utilize the spent acid from explosives manufacture and inability to move phosphate rock would interfere with this plan.

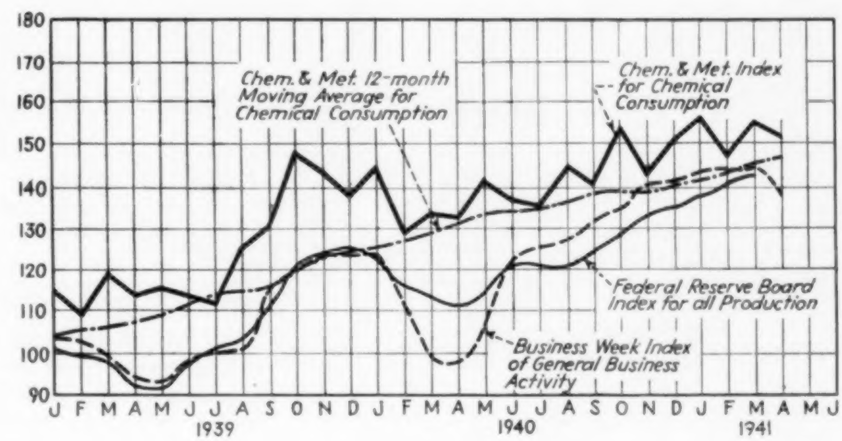
Chem. & Met.'s Weighted Index For Chemical Consumption

	February revised	March
Fertilizer	30.08	30.84
Pulp and paper	20.25	22.10
Petroleum refining	13.21	14.37
Glass	13.57	14.90
Paint and varnish	10.94	13.05
Iron and steel	12.05	13.30
Rayon	11.63	12.20
Textiles	10.05	10.76
Coal products	8.71	9.63
Leather	4.58	4.74
Explosives	4.91	5.21
Rubber	3.51	3.86
Plastics	3.32	3.58
	146.81	158.54

The fertilizer industry has shown a seasonal let-down in recent weeks but other industries have either increased activities or increased them except in instances where the coal supply has been curtailed. The weighted index for consumption of chemicals for April reflected this to a slight extent and the number for April stands at 153 as against a revised figure of 158.54 for March and 146.81 for February. Last year the corresponding indexes were 132.99, 133.61, and 129.22 respectively.

In view of reports that current shortages in methanol and formaldehyde were due to partial turning over of methanol plants to produce ammonia for nitric acid manufacture, it is noted that the figures for March show a marked rise in methanol production over the February figures but both the synthetic and the crude products are being produced at levels considerably below plant capacities. The question of shifting plant production where the equipment offers this flexibility and of substituting raw materials and even finished products may become important to the individual manufacturer later on. The first industry change on a definite scale is found in the announcement that automotive production would be curtailed 10 percent in the coming fiscal year. While plant facilities will not be reduced, the change in operations will mean a shift in raw material requirements. The Army is trying an experiment in buying shoes with composition soles. The use of plastics is suggested in lines where they are capable of replacing the metals essential in the national defense. Multiplication of such plans to adjust total production according to the relative importance of the manufactured product and to the availability of raw material supplies may have a decided effect on individual and industry production schedules.

In the meantime, export business in chemicals is holding up to recently established standards with nearly all divisions showing substantial gains in March over the corresponding period of last year. Exports of industrial chemicals in March ran in excess of \$5,000,000, coal-tar chemicals reached a valuation of more than \$2,700,000,

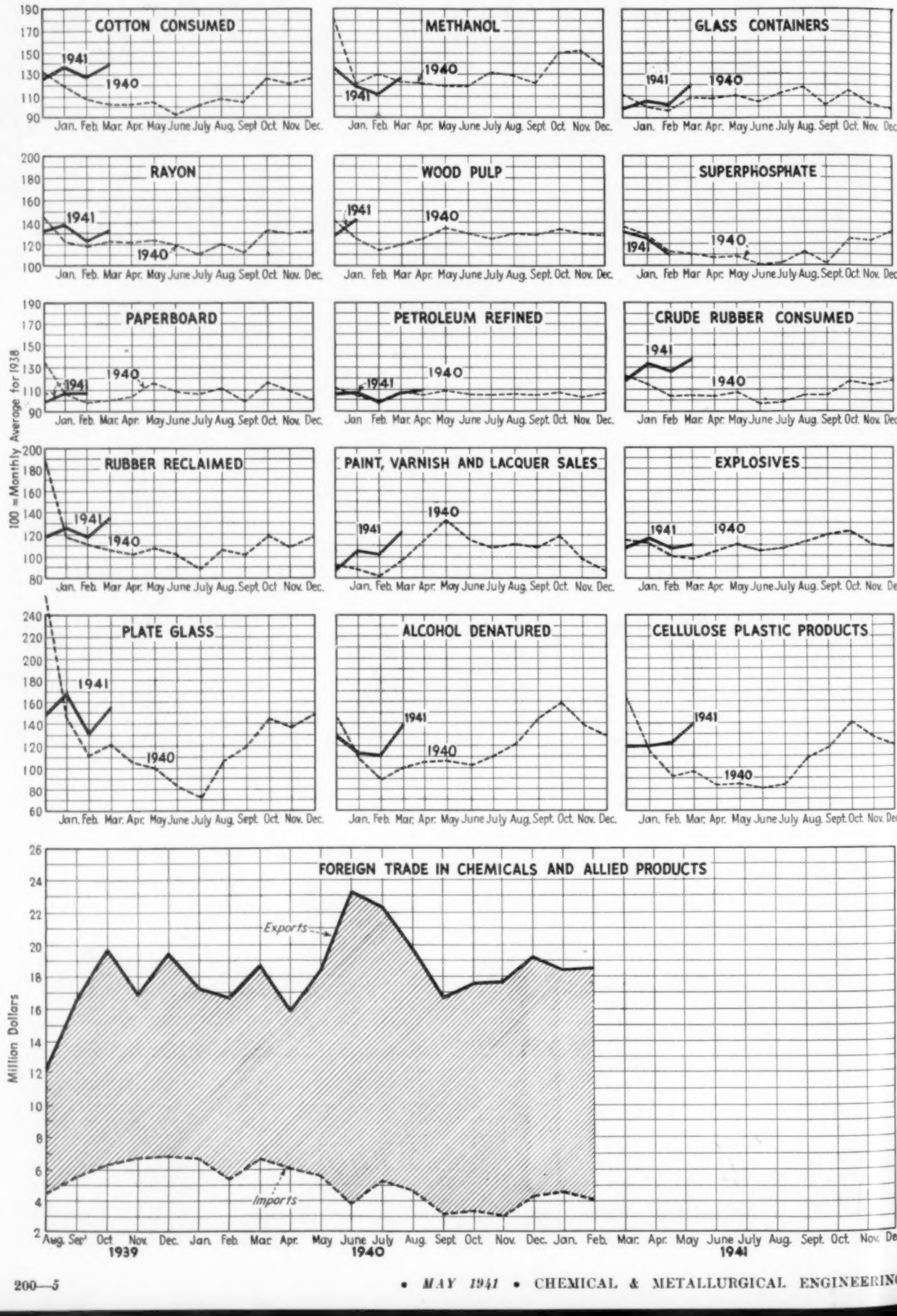


Production and Consumption Data for Chemical-Consuming Industries

Production	March 1940	March 1941	January-March 1941	January-March 1940	Per cent of gain for 1941
Alcohol, ethyl, 1,000 pr. gal	21,702	20,983	67,956	62,016	9.4
Alcohol denatured, 1,000 wi. gal	13,192	9,524	34,358	28,383	21.1
Ammonia liquor, 1,000 lb	5,490	4,504	15,499	13,845	11.9
Ammonium sulphate, tons	64,524	56,059	187,553	169,927	10.4
Benzol, 1,000 gal	13,305	9,952	38,200	31,070	22.4
Toluol, 1,000 gal	2,348	....	6,851	....	....
Naphthalene, 1,000 lb	6,557	....	19,021	....	....
Automobiles, no	507,868	423,620	1,494,322	1,259,931	18.6
Byproduct coke, 1,000 tons	4,999	4,125	14,434	12,849	12.3
Glass containers, 1,000 gr	5,128	4,606	14,010	12,992	7.8
Plate glass, 1,000 sq. ft	18,266	14,302	53,280	44,734	19.1
Window glass, 1,000 boxes	1,417	1,107	4,375	3,619	20.9
Methanol, synthetic, 1,000 gal	3,673	3,463	10,263	10,698	4.1*
Nitrocellulose plastics, 1,000 lb	1,308	1,090	3,606	3,345	7.8
Cellulose acetate plastics, 1,000 lb.					
Sheets, rods, and tubes	465	550	1,523	2,044	22.5*
Molding composition	2,232	1,104	5,742	3,253	76.5
Pyroxylin spread, 1,000 lb	6,692	4,769	18,947	14,831	27.8
Rubber reclaimed, tons	22,006	17,234	61,926	54,523	13.6
Consumption					
Cotton, bales	854,179	627,194	2,491,079	2,020,758	23.3
Silk, bales	25,828	21,685	82,364	73,676	11.8
Wool, 1,000 lb	49,680	25,049	147,704	92,901	59.0
Explosives, 1,000 lb	35,722	30,189	105,433	95,914	9.9
Rubber, crude, tons	66,821	50,192	192,062	155,002	23.9
Rubber, reclaimed, tons	19,149	15,931	55,578	47,371	17.3

* Percent of decline.

Production and Consumption Trends



Contents

LIMITED SUPPLY OF NUMEROUS CHEMICALS RESTRICTS TRADING IN THE OPEN MARKET

The most important feature to the chemical market at present is the growing number of items which are difficult to obtain in open trading. As plants engaged in purely defense work get into fuller production, they are increasing their demands for raw materials. This comes at a time when general activity is at a high level and the combination of circumstances is placing a strain on manufacturers to turn out materials in the desired quantities. The big question at the moment, therefore, is concerned with the ability of the chemical industry to turn out goods in larger volume. Plant facilities have been expanded in many cases but the answer cannot be found in still further expansion because difficulties are met in the way of getting certain types of equipment and also in finding raw materials which would warrant larger productions. One of the chemicals which has attracted attention recently because of its sold-up position is phthalic anhydride. Early in the month one producer announced plans for a new plant to make this chemical which gives promise of later relief in supply. In other cases, solutions to the supply problem do not appear to be in sight and scarcity of certain chemicals seems assured for some time to come.

Contract withdrawals continue to take up the greater part of present production and spot trading is limited by this fact although considerable interest is shown in many selections. The price movement continues upward although, if resale lots are disregarded, the net rise has been very moderate. Increase in production costs, however, have been almost general and this gives a strong undertone which suggests that any adjustments which may be made later will be in an upward direction.

In contrast to the relatively steady position of chemicals, are the day by day fluctuations in values for oils and fats. The sharp rise in values reported a month ago have been followed by equally sharp advances in the intervening period. With the exception of linseed oil, the advances were pronounced, taking in both domestic and foreign products. The imported oils are at a disadvantage because higher transportation charges and lack of shipping space have interrupted their normal movement. Imports of edible oils in March amounted to 1,491,000 lb. as compared with 5,113,000 lb. in March last year and despite the higher unit price imports of inedible oils were valued at \$3,024,000 as against \$4,535,000 in March 1940. Imports of oilseeds also have been more than cut in two, all of which offers some explanation for the recent upsurge of prices in domestic markets.

Of considerable importance to manufacturers of chemicals is the new form of inventory control announced by the Office of Production Management on May 1. The first announcement specified 16 metals, most of which figure in the making of chemicals. The control is aimed at checking inventories and provides that both consumers and suppliers of these metals file sworn statements covering compliance with the regulations. In this connection the term inventories refers not only to the metals but also to products made from them. One provision of the order reads as follows: "Further, after the 10th day of each calendar month, commencing June 10, 1941, no supplier shall make any delivery to any customer unless such supplier shall have received from such customer a sworn statement covering inventories during the preceding calendar month, in the form attached to this order and marked PD-19B."

The movement of chemicals and other products likewise is receiving attention and all shippers and receivers of freight are asked to give advance notice of car requirements but not to order cars until ready to load; to unload promptly and notify railroad when empties are available; load to maximum journal carrying capacity or full visible capacity, whichever governs; remove all dunnage, blocking and rubbish after unloading to permit immediate reuse; in industries where five-day week is in effect, to provide at least six-day facilities for loading and unloading cars.

Prices for naval stores which had been climbing a few weeks ago turned in the opposite direction later on and an easy tone is now noted in the market. As the new season has advanced arrivals from interior points have gained in volume and reports have been circulated to the effect that production would be larger than had been anticipated.

Production of sodium sulphate from natural brines and saline deposits

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CHEM. & MET.

Weighted Index of

CHEMICAL PRICES

Base=100 for 1937

This month	**100.35**
Last month	100.14
May, 1940	98.71
May, 1939	97.27

The price tone continues strong with a growing list of chemicals which are difficult to obtain in the open market. Contract deliveries take up the bulk of current production and in many cases export inquiries go unfilled.

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in the United States increased 36 percent in 1940 following a 71 percent increase in 1939 over the previous record output in 1938. Output of natural sodium carbonates increased 4 percent and shipments of borax and other boron derivatives decreased slightly in 1940, according to reports of producers to the Bureau of Mines.

Producers of natural salt cake, being favorably situated to the Southern producers of sulphate pulp, operated at capacity during 1940 in an effort to replace the supply of salt cake which formerly came from Europe. In consequence, domestic sales of natural sodium sulphate reached the all-time high level of 187,233 short tons valued at $1,528,633. During the latter part of the year, supplementing supplies from natural sources and from chemical plants, large scale production of "synthetic salt cake", a sintered mixture of sulphate and soda ash in the ratio of about 3 parts of sulphate to 10 parts of soda ash was reported at Lake Charles, La., at the rate of several hundred tons a day.

In addition to salt cake, the Bureau of Mines figures for sodium sulphate include smaller quantities of burkeite (a double sulphate and carbonate) and Glauber's salt.

The imports of salt cake (crude) which dropped from 220,176 tons in 1937 to 142,429 tons in 1938, and made the slight increase to 148,794 tons valued at $1,394,484 in 1939, amounted to 73,027 tons valued at $1,009,694 in 1940, a decline of 51 percent in quantity. Germany which has hitherto supplied most of the imported salt cake, being credited with a total of 103,259 short tons valued at $931,553 in 1939, supplied but 2,240 tons valued at $24,000 in 1940. The United Kingdom, (21,856 tons, value $269,818), Canada (16,444 tons, value $241,982), Chile (8,445 tons, value $146,798), and France (9,290 tons, value $113,452) increased their shipments to this country in 1940, and those of Belgium were curtailed (14,202 tons, value $209,394). The increase in import of salt cake from Chile was disappointingly below expectation, imports for 1940 being less than one-third of the 1938 imports of salt cake.

CHEM. & MET.

Weighted Index of Prices for

OILS & FATS

Base=100 for 1937

This month	**108.79**
Last month	93.76
May, 1940	78.88
May, 1939	70.85

With the exception of linseed oil, the price movement for oils and fats has continued upward and in the case of some of the imported oils, prices are largely nominal with offerings restricted.

Chem & Met Current PRICES

INDUSTRIAL CHEMICALS

	Current Price	Last Month	Last Year
Acetone, drums, lb	$0.07½–$0.08	$0.07½–$0.08	$0.07½–$0.07¾
Acid, acetic, 28%, bbl., cwt	2.23 – 2.48	2.23 – 2.48	2.23 – 2.48
Glacial 99%, drums	8.43 – 8.68	8.43 – 8.68	8.43 – 8.68
U. S. P. Reagent	10.25 –10.50	10.25 –10.50	10.25 –10.50
Boric, bbl., ton	106.00–111.00	106.00–111.00	106.00–111.00
Citric, kegs, lb	.20 – .23	.20 – .23	.20 – .23
Formic, cbys., lb	.10½– .11	.10½– .11	.10½– .11
Gallic, tech., bbl., lb	.90 – 1.00	.90 – 1.00	.90 – 1.00
Hydrofluoric 30% drums, lb	.08 – .08½	.08 – .08½	.08 – .08½
Lactic, 44%, tech., light, bbl., lb	.06½– .06¾	.06½– .06¾	.06½– .06¾
Muriatic, 18°, tanks, cwt	1.05 –	1.05 –	1.05 –
Nitric, 36°, carboys, lb	.05 – .05½	.05 – .05½	.05 – .05½
Oleum, tanks, wks., ton	18.50 –20.00	18.50 –	18.50 –20.00
Oxalic, crystals, bbl., lb	.10¾– .12	.10¾– .12	.10¾– .12
Phosphoric, tech, c'bys., lb	.07½– .08½	.07½– .08½	.07½– .08½
Sulphuric, 60°, tanks, ton	13.00 –	13.00 –	13.00 –
Sulphuric, 66°, tanks, ton	16.50 –	16.50 –	16.50 –
Tannic, tech, bbl., lb	.54 – .56	.54 – .56	.54 – .56
Tartaric, powd., bbl., lb	.63 –	.63 –	.37½–
Tungstic, bbl, lb	nom	nom	nom
Alcohol, amyl	–	–	–
From Pentane, tanks, lb	.111–	.111–	.101–
Alcohol, Butyl, tanks, lb	.09 –	.09 –	.09 –
Alcohol, Ethyl, 190 p'f., bbl., gal	6.04 –	6.04 –	4.54 –
Denatured, 190 proof	–	–	–
No. 1 special, dr., gal. wks	.33 –	.32 –	.29½–
Alum, ammonia, lump, bbl., lb	.03½– .04	.03½– .04	.03½– .04
Potash, lump, bbl., lb	.03¾– .04	.03¾– .04	.03¾– .04
Aluminum sulphate, com. bags, cwt	1.15 – 1.40	1.15 – 1.40	1.15 – 1.40
Iron free, bg., cwt	1.60 – 1.70	1.60 – 1.70	1.60 – 1.70
Aqua ammonia, 26°, drums, lb	.02¾– .03	.02¾– .03	.02¾– .03
tanks, lb	.02 – .02½	.02 – .02½	.02 – .02½
Ammonia, anhydrous, cyl., lb	.16 –	.16 –	.16 –
tanks, lb	.04½–	.04½–	.04½–
Ammonium carbonate, powd. tech., casks, lb	.09 – .12	.09 – .12	.09 – .12
Sulphate, wks., cwt	1.45 –	1.45 –	1.40 –
Amylacetate tech., from pentane, tanks, lb	.10½–	.10½–	.10½–
Antimony Oxide, bbl., lb	.12 –	.12 –	.15 –
Arsenic, white, powd., bbl., lb	.03½– .04	.03½– .04	.03 – .03½
Red, powd., kegs, lb	nom	nom	.17– .18
Barium carbonate, bbl., ton	52.50 –57.50	52.50 –57.50	52.50 –57.50
Chloride, bbl., ton	79.00 –81.00	79.00 –81.00	79.00 –81.00
Nitrate, casks, lb	.09½– .10	.08½– .10	.07 – .08
Blanc fixe, dry, bbl., lb	.03½– .04	.03½– .04	.03½– .04
Bleaching powder, f.o.b., wks., drums, cwt	2.00 – 2.10	2.00 – 2.10	2.00 – 2.10
Borax, gran., bags, ton	43.00 –	43.00 –	43.00 –51.00
Bromine, cs., lb	.30 – .32	.30 – .32	.30 – .32
Calcium acetate, bags	1.90 –	1.90 –	1.90 –
Arsenate, dr., lb	.06½– .06¾	.06½– .06¾	.06¾– .07
Carbide drums, lb	.04¾– .05	.04¾– .05	.04¾– .05
Chloride, fused, dr., del., ton	19.00 –24.50	19.00 –24.50	21.50 –24.50
flake, dr., del., ton	20.50 –25.00	20.50 –25.00	23.00 –25.00
Phosphate, bbl., lb	.07½– .08	.07½– .08	.07½– .08
Carbon bisulphide, drums, lb	.05 – .06	.05 – .06	.05 – .06
Tetrachloride drums, lb	.04¾– .05½	.04¾– .05½	.04¾– .05½
Chlorine, liquid, tanks, wks., lb	1.75 –	1.75 –	1.75 –
Cylinders	.05½– .06	.05½– .06	.05½– .06
Cobalt oxide, cans, lb	1.84 – 1.87	1.84 – 1.87	1.84 – 1.87
Copperas, bgs., f.o.b. wks, ton	18.00 –19.00	18.00 –19.00	18.00 –19.00
Copper carbonate, bbl., lb	.10 – .16½	.10 – .16½	.10 – .16
Sulphate, bbl., cwt	4.75 – 5.00	4.75 – 5.00	4.60 – 4.85
Cream of tartar, bbl., lb	.52 –	.52 –	.30¾–
Diethylene glycol, dr., lb	.22 – .23	.22 – .23	.22 – .23
Epsom salt, dom.,tech., bbl., cwt	1.80 – 2.00	1.80 – 2.00	1.80 – 2.00
Ethyl acetate, drums, lb	.07½–	.07½–	.07 –
Formaldehyde, 40%, bbl., lb	.05½– .06	.05½– .06½	.05¾– .06¼
Furfural, tanks, lb	.09 –	.09 –	.09 –
Fusel oil, drums, lb	.16 – .17	.16 – .17	.16 – .17
Glaubers, salt, bags, cwt	.95 – 1.00	.95 – 1.00	.95 – 1.00
Glycerine, c.p., drums, extra, lb	.12½–	.12½–	.12½–
Lead:			
White, basic carbonate, dry casks, lb	.07½–	.07½–	.07 –
White, basic sulphate, sck., lb	.07¼–	.07¼–	.06½–
Red, dry, sck., lb	.0835	.0835	.07⅛–
Lead acetate, white crys, bbl., lb	.11 – .12	.11 – .12	.11 – .12
Lead arsenate, powd., bag, lb	.09½– .11	.09½– .11	.08½– .11
Lime, chem., bulk, ton	8.50 –	8.50 –	8.50 –
Litharge, pwd., csk., lb	.0735	.0735	.06½–
Lithophone, bags, lb	.0385 .04	.0385 .04	.036– .04
Magnesium carb., tech., bags, lb	.06¼– .06½	.06¼– .06½	.06¼– .06½

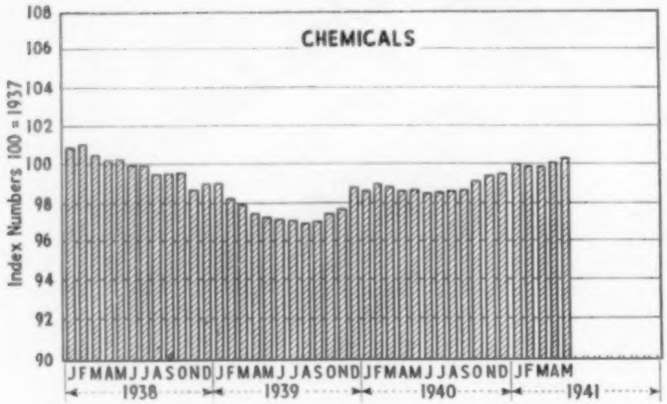
The accompanying prices refer to round lots in the New York market. Where it is the trade custom to sell f.o.b. works, quotations are given on that basis and are so designated. Prices are corrected to May 13

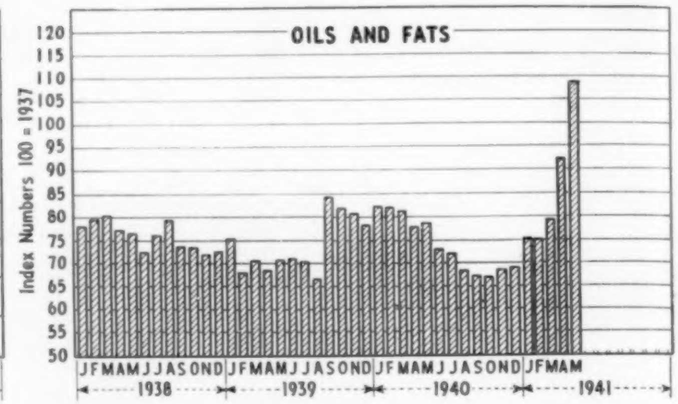
	Current Price	Last Month	Last Year
Methanol, 95%, tanks, gal	.29 –	.29 –	.29 –
97%, tanks, gal	.30 –	.30 –	.30 –
Synthetic, tanks, gal	.30 –	.30 –	.30 –
Nickel salt, double, bbl., lb	.13¼– .13½	.13¼– .13½	.13 – .13½
Orange mineral, csk., lb	.11¼–	.11¼–	.10¼–
Phosphorus, red, cases, lb	.40 – .42	.40 – .42	.40 – .42
Yellow, cases, lb	.18 – .25	.18 – .25	.18 – .25
Potassium bichromate, casks, lb	.08⅝– .09	.08⅝– .09	.08⅝– .09
Carbonate, 80–85%, calc. csk., lb	.06½– .07	.06½– .07	.06½– .07
Chlorate, powd., lb	.10 – .12	.10 – .12	.10 – .12
Hydroxide(c'stic potash) dr., lb	.07 – .07½	.07 – .07½	.07 – .07½
Muriate, 80% bags, unit	.53½–	.53½–	.53½–
Nitrate, bbl., lb	.05½– .06	.05½– .06	.05½– .06
Permanganate, drums, lb	.19½– .20	.19½– .20	.18½– .19
Prussiate, yellow, casks, lb	.16 – .17	.15 – .16	.15 – .16
Sal ammoniac, white, casks, lb	.0515 .06	.0515 .06	.05½– .06
Salsoda, bbl., cwt	1.00 – 1.05	1.00 – 1.05	1.00 – 1.05
Salt cake, bulk, ton	17.00 –	17.00 –	23.00 –
Soda ash, light, 58%, bags, contract, cwt	1.05 –	1.05 –	1.05 –
Dense, bags, cwt	1.10 –	1.10 –	1.10 –
Soda, caustic, 76%, solid, drums, cwt	2.30 – 3.00	2.30 – 3.00	2.30 – 3.00
Acetate, works, bbl., lb	.04 – .05	.04 – .05	.04 – .05
Bicarbonate, bbl., cwt	1.70 – 2.00	1.70 – 2.00	1.70 – 2.00
Bichromate, casks, lb	.06¾– .07	.06¾– .07	.06¾– .07
Bisulphate, bulk, ton	16.00 –17.00	16.00 –17.00	15.00 –16.00
Bisulphite, bbl., lb	.03 – .04	.03 – .04	.03½– .04
Chlorate, kegs, lb	.06¼– .06½	.06¼– .06½	.06¼– .06½
Cyanide, cases, dom., lb	.14 – .15	.14 – .15	.14 – .15
Fluoride, bbl., lb	.07 – .08	.07 – .08	.07½– .08
Hyposulphite, bbl., cwt	2.40 – 2.50	2.40 – 2.50	2.40 – 2.50
Metasilicate, bbl., cwt	2.35 – 2.40	2.35 – 2.40	2.20 – 3.20
Nitrate, bulk, cwt	1.45 –	1.45 –	1.45 –
Nitrite, casks, lb	.06¾– .07	.06¾– .07	.06¾– .07
Phosphate, tribasic, bags, lb	2.35 –	2.35 –	2.25 –
Prussiate, yel. drums, lb	.10½– .11	.10½– .11	.10½– .11
Silicate (40° dr.) wks., cwt	.80 – .85	.80 – .85	.80 – .85
Sulphide, fused, 60–62%, dr. lb	.02¾– .03½	.02¾– .03	.02¾– .03
Sulphite, crys, bbl., lb	.02¼– .02½	.02¼– .02½	.02¼– .02½
Sulphur, crude at mine, bulk, ton	16.00 –	16.00 –	16.00 –
Chloride, dr., lb	.03 – .04	.03 – .04	.03 – .04
Dioxide, cyl., lb	.07 – .08	.07 – .08	.07 – .07½
Flour, bag, cwt	1.60 – 3.00	1.60 – 3.00	1.60 – 3.00
Tin Oxide, bbl., lb	mon	.54 –	.51 –
Crystals, bbl., lb	.39 –	.39 –	.36 –
Zinc, chloride, gran, bbl., lb	.05 – .06	.05 – .06	.05 – .06
Carbonate, bbl., lb	.14 – .15	.14 – .15	.14 – .15
Cyanide, dr., lb	.33 – .35	.33 – .35	.33 – .35
Dust, bbl., lb	.09¼–	.09¼–	.07¾–
Zinc oxide, lead free, bag, lb	.06½–	.06½–	.06½–
5% lead sulphate, bags, lb	.06¾–	.06¾–	.06¼–
Sulphate, bbl., cwt	3.15 – 3.25	3.15 – 3.25	2.75 – 3.00

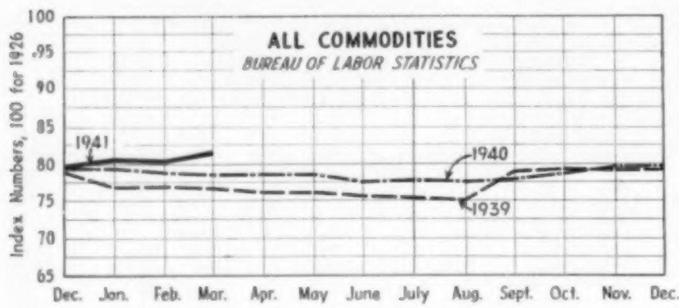
OILS AND FATS

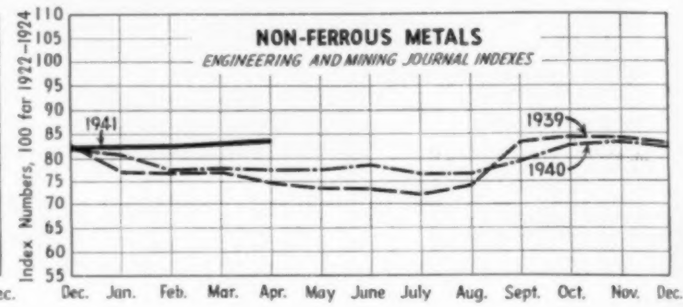
	Current Price	Last Month	Last Year
Castor oil, 3 bbl., lb	$0.11 –$0.11½	$0.10½–$0.11	$0.11½–$0.12
Chinawood oil, bbl., lb	.31 –	.29 –	.24 –
Coconut oil, Ceylon, tank, N. Y., lb	.07 –	.05½–	.03½–
Corn oil crude, tanks (f.o.b. mill), lb	.09½–	.08 –	.06¼–
Cottonseed oil, crude (f.o.b. mill), tanks, lb	.09½–	.07½–	.05¾–
Linseed oil, raw car lots, bbl., lb	.109–	.105–	.106–
Palm, casks, lb	.05¾–	.05–	.04½–
Peanut oil, crude, tanks (mill), lb	.09¾–	.08 –	.06¼–
Rapeseed oil, refined, bbl., lb	.12 –	.12 –	.12 –
Soya bean, tank, lb	.08½–	.07½–	.05¾–
Sulphur (olive foots), bbl., lb	.14½–	.12½–	.08½–
Cod, Newfoundland, bbl., gal	nom	nom	nom
Menhaden, light pressed, bbl., lb	.10 –	.09 –	.073–
Crude, tanks (f.o.b. factory), gal	.50 –	.44 –	.33 –
Grease, yellow, loose, lb	.06½–	.06½–	.04¾–
Oleo stearine, lb	.09½–	.08 –	.06½–
Oleo oil, No. 1	.10½–	.08½–	.06¾–
Red oil, distilled, d.p. bbl., lb	.10½–	.09 –	.08 –
Tallow extra, loose, lb	.07½–	.07 –	.04½–

Chem. & Met.'s Weighted Price Indexes









Coal-Tar Products

	Current Price	Last Month	Last Year
Alpha-napthol, crude bbl., lb	$0.52 -$0.55	$0.52- $0.55	$0.52 -$0.55
Alpha-naphthylamine, bbl., lb	.32 - .34	.32 - .34	.32 - .34
Aniline oil, drums, extra, lb	.15 - .16	.15 - .16	.15 - .16
Aniline, salts, bbl., lb	.22 - .24	.22 - .24	.22 - .24
Benzaldehyde, U.S.P., dr., lb	.85 - .95	.85 - .95	.85 - .95
Benzidine base, bbl., lb	.70 - .75	.70 - .75	.70 - .75
Benzoic acid, U.S.P., kgs., lb	.54 - .56	.54 - .56	.54 - .56
Benzyl chloride, tech., dr., lb	.23 - .25	.23 - .25	.23 - .25
Benzol, 90%, tanks, works, gal	.14 -......	.14 - .14	.16 - .18
Beta-napthol, tech., drums, lb	.23 - .24	.23 - .24	.23 - .24
Cresol, U.S.P., dr., lb	.09½- .10	.09½- .10	.09½- .10
Cresylic acid, dr., wks., gal	.58 - .60	.58 - .60	.58 - .60
Diethylaniline, dr., lb	.40 - .45	.40 - .45	.40 - .45
Dinitrophenol, bbl., lb	.23 - .25	.23 - .25	.23 - .25
Dinitrotoluol, bbl., lb	.15½- .16	.15½- .16	.15½- .16
Dip oil, 15%, dr., gal	.23 - .25	.23 - .25	.23 - .25
Diphenylamine, dr. f.o.b wks., lb	.70 -......	.70........	....
H-acid, bbl., lb	.45 - .50	.45 - .55	.50 - .55
Naphthalene, flake, bbl., lb	.07 - .07¼	.07 - .07¼	.06¾- .07
Nitrobenzene, dr., lb	.08 - .09	.08 - .09	.08 - .09
Para-nitraniline, bbl., lb	.47 - .49	.47 - .49	.47 - .49
Phenol, U.S.P., drums, lb	.12 -......	.12 -......	.13 -......
Picric acid, bbl., lb	.35 - .40	.35 - .40	.35 - .40
Pyridine, dr., gal	1.70 - 1.80	1.70 - 1.80	1.70 - 1.80
Resorcinol, tech., kegs, lb	.75 - .80	.75 - .80	.75 - .80
Salicylic acid, tech., bbl., lb	.33 - .40	.33 - .40	.33 - .40
Solvent naptha, w.w., tanks, gal	.27 -......	.27 -......	.27 -......
Tolidine, bbl., lb	.86 - .88	.86 - .88	.86 - .88
Toluol, drums, works, gal	.30 -......	.30 -......	.30 -......
Xylol, com, tanks, gal	.26 -......	.26 -......	.27 -......

Miscellaneous

	Current Price	Last Month	Last Year
Barytes, grd., white, bbl., ton	$22.00-$25.00	$22.00-$25.00	$22.00-$25.00
Casein, tech, bbl., lb	.16 - .17	.12½- .13	.11 - .13
China clay, dom., f.o.b. mine, ton	8.00 -20.00	8.00 -20.00	8.00 -20.00
Dry colors			
Carbon gas, black (wks.), lb	.03¼- .30	.03¼- .30	.028- .30
Prussian blue, bbl., lb	.36 - .37	.36 - .37	.36 - .37
Ultramarine blue, bbl., lb	.11 - .26	.11 - .26	.10 - .26
Chrome green, bbl., lb	.21½- .30	.21½- .30	.21 - .27
Carmine, red, tins, lb	4.60 - 4.75	4.85 - 5.00	4.85 - 5.00
Para toner, lb	.75 - .80	.75 - .80	.75 - .80
Vermilion, English, bbl., lb	3.20 - 3.25	3.12 - 3.20	2.46 - 2.50
Chrome yellow, C.P., bbl., lb	.14½- .15½	.14½- .15½	.14½- .15½
Feldspar, No. 1 (f.o.b. N.C.), ton	6.50 - 7.50	6.50 - 7.50	6.50 - 7.50
Graphite, Ceylon, lump, bbl., lb	.08 - .10	.06 - .06½	.06 - .06½
Gum copal Congo, bags, lb	.08 - .30	.08 - .30	.06 - .30
Manila, bags, lb	.09 - .15	.09 - .14	.09 - .14
Damar, Batavia, cases, lb	.10 - .22	.10 - .20	.08 - .24
Kauri, cases, lb	.18 - .60	.18 - .60	.18½- .60
Kieselguhr (f.o.b. mines), ton	7.00 -40.00	7.00 -40.00	7.00 -40.00
Magnesite, calc, ton	65.00 -......	65.00 -......	65.00 -......
Pumice stone, lump. bbl., lb	.05 - .07	.05 - .08	.05 - .07
Imported, casks, lb	nom	.03 - .04	.03 - .04
Rosin, H., 100 lb	2.52 -......	2.58 -......	.... -......
Turpentine, gal	.47¾-......	.49 -......	.34 -......
Shellac, orange, fine, bags, lb	.34 -......	.34 -......	.27 -......
Bleached, bonedry, bags, lb	.31½-......	.31½-......	.25 -......
T. N. Bags, lb	.24 -......	.24 -......	.14½-......
Soapstone (f.o.b. Vt.), bags, ton	10.00 -12.00	10.00 -12.00	10.00 -12.00
Talc. 200 mesh (f.o.b. Vt.), ton	8.00 - 8.50	8.00 - 8.50	8.00 - 8.50
200 mesh (f.o.b. Ga.), ton	6.00 - 8.00	6.00 - 8.00	7.50 -11.00

Industrial Notes

AMERICAN MACHINE AND METALS, INC., East Moline, Ill., announces the following changes in the Tolhurst Centrifugal Division: Howard H. Harlan recently manager at New York goes to Washington where he will become technical assistant to the general sales manager; George P. Hebard becomes field sales promotion manager; J. R. Angel will manage the New York office; and W. C. Davis will be in charge at Atlanta.

THE CINCINNATI RUBBER MFG. CO., Cincinnati, has appointed John Flocker & Co., Pittsburgh, as its representative in that territory.

NATIONAL ENGINEERING CO., Chicago, has appointed Barney Castor as sales and service engineer in the Los Angeles territory with headquarters at 1957 Fletcher Ave., South Pasadena.

AMERICAN FIRSTOLINE CORP., Long Island City, N. Y., has taken over the general sales management for the Gulton Metal Refining & Chemical Corp.

B. F. GOODRICH CO., Akron, announces that the newly formed Flexlock Corp. has been given exclusive distribution for the Flexlock rubber gasket manufactured by the company. T. D. Nathan is sales manager with offices at 411 East Market St.

AMERICAN CYANAMID CO., New York, has changed the name of its Beetle Products Division to Plastics Division. C. J. Romieux is sales manager and Dr. K. E. Ripper heads its technical activities.

DIAMOND ALKALI CO., Pittsburgh, has appointed The Commerce Petroleum Co., Chicago, as distributor of its chlorinated solvents.

OHMITE MFG. CO., Chicago, has advanced Roy S. Laird to the position of sales manager of the company.

AMPCO METAL CO., Milwaukee, has placed Sherman Barnes in charge of its western New York sales territory with headquarters at 239 Burr St., Rochester. Mr. Barnes succeeds W. B. McKenzie who has been moved to the Chicago office.

AMERICAN K. A. T. CORP., New York, has opened an office in the Commercial Trust Bldg., Philadelphia, with Frank Campbell Coe in charge.

MOUND CITY PAINT & COLOR CO., St. Louis, has appointed Dr. F. W. Ottens general superintendent of operations.

UNIVERSAL OIL PRODUCTS CO., Chicago, has licensed the Ohio Oil Co. to install a catalytic polymerization unit in its refinery at Robinson, Ill.

MANNING, MAXWELL & MOORE, Bridgeport, Conn., has added Leo W. Dillon to its sales staff in the Kansas City territory. Herman M. Munson will work in Chicago and Frederick W. Chadwick will make his headquarters in Syracuse.

He *has* to take chances

A lion tamer risks his life every time he steps into the cage—and faces hundreds of pounds of power and ferocity that may go berserk at any moment. Even a revolver might be inadequate protection. He *has* to take chances.

Many shippers who use drums are taking chances, too—with tampering, leakage and waste. Yet these risks are never necessary. You can make sure *every drop* of your product is safe *every second* by equipping your drums with Tri-Sure Closures.

Tri-Sure Closures have a seal which cannot be removed unless it is deliberately destroyed, a plug which is always held tightly in place, a flange which assures complete drainage. This *triple* protection is *perfect* protection to your product and your reputation—to you and your customers. Be sure every shipment has it. Write today for booklet containing complete information.

AMERICAN FLANGE & MANUFACTURING CO. INC.
30 Rockefeller Plaza, New York

Tri-Sure

Reg. U. S. Pat. Off.

CLOSURES

Chem & Met New CONSTRUCTION

	Current Projects — Proposed Work	Current Projects — Contracts	Cumulative 1941 — Proposed Work	Cumulative 1941 — Contracts
New England	$60,000	$2,750,000	$230,000	$3,506,000
Middle Atlantic	290,000	580,000	13,050,000	15,932,000
South	1,148,000	10,500,000	11,593,000	7,995,000
Middle West	790,000	100,000	2,685,000	2,645,000
West of Mississippi	2,275,000	1,512,000	8,105,000	9,097,000
Far West	42,000	1,945,000	1,122,000	15,499,000
Canada	90,000	....	610,000	170,000
Total	$4,695,000	$17,387,000	$37,395,000	$54,844,000

PROPOSED WORK

Ia., Des Moines—Marquette Cement Manufacturing Co., 140 South Dearborn St., Chicago, Ill., plans to construct a new plant addition at 52nd St. and Park Ave., here, including a kiln 475 ft. long and a large amount of new equipment. Estimated cost $2,000,000.

Ga., Savannah—Nelio Resin Processing Corp., Jacksonville, Fla., plans to construct a plant here. Estimated cost $150,000.

N. H., West Hopkinton—Davis Paper Co., West Hopkinton, will soon award the contract for a 1 story plant. Estimated cost $60,000.

N. J., Newark—Pittsburgh Plate Glass Co., 4 Chester Ave., Newark, N. J., plans to construct a new factory. John H. and Wilson C. Ely, 744 Broad St., Newark, Archts.

N. Y., Corning—Corning Glass Works, Walnut St., plans to construct a 2 story, 100x350 ft. factory. A. Vaksdal, c/o owner, Engr. Estimated cost $150,000.

O., Barberton—Pittsburgh Plate Glass Co., Walter Farst in charge, plans to construct a drum storage building, a hoist house and office building here. Good & Wagner, First Central Tower Bldg., Akron, Archt. Frank Erosky, 7829 Euclid Ave., Cleveland, Engr. Estimated cost $40,000.

O., Cleveland—Cleveland Graphite Bronze Co., B. F. Hopkins, Pres., will soon award the contract for a group of buildings including a 1 story, 343x683 ft. main factory building and 1 story 163x252 ft. castings building. John H. Graham, 603 Hanna Bldg., Cleveland, Archt. Estimated cost $750,000.

Pa., Creighton—Pittsburgh Plate Glass Co., Grant Bldg., Pittsburgh, is having plans prepared by Ralph D. Bole, chief engineer care of company, and will soon take bids for the construction of a 4 story, 30x228 ft. safety glass manufacturing building. Estimated cost $100,000.

Tex., Freer—Benedum & Trees, San Diego and Freer, plan to construct a gasoline plant in Duval Co. in the vicinity of Freer. Estimated cost $125,000.

Tex., San Diego—Champlin & Bass, c/o Oil Fraternity, Dallas, plan to construct a recycling plant in the Sejita Fields. Estimated cost $150,000.

Wash., Fort Lewis—War Dept., Wash., D. C., plans to construct a medical corps laboratory here. Estimated cost $42,177.

W. Va., Sandyville—Anchor Hocking Glass Corp., Lancaster, O., plans to construct a natural gas pipe line from the gas fields near Sandyville to supply two glass manufacturing plants near Lancaster. Estimated cost $998,330.

B. C., New Westminster—Westminster Paper Co. plans to remodel and construct additions to its mill here. Estimated cost $50,000.

Que., Lennoxville—Philip Carey Co., Ltd., College St., plans to construct an addition to its asbestos manufacturing plant. Estimated cost $40,000.

CONTRACTS AWARDED

Calif., Emeryville—Plant Rubber & Asbestos Co., 537 Brannan St., San Francisco, has awarded the contract for a plant for the manufacture of 85% magnesia, an insulating material, to Cahill Bros., 206 Sansome St., San Francisco. Estimated cost $250,000.

Calif., Los Angeles—Pioneer Division, Flintkote Co., 5500 South Alameda St., Vernon, has awarded the contract for a 1 and 2 story laboratory to S. McKittrick Co., 7839 Santa Fe Ave. Estimated cost $40,000.

Calif., San Francisco—Metten & Gebhardt, 135 Trumbull St., have awarded the contract for a tannery to A. H. Wilhelm, 666 Mission St., San Francisco, at $45,265.

Conn., Wallingford—Plastics Div. of American Cyanamid Corp., West Main St., has awarded the contract for two 3 story, 100x250 ft. factory units to Miller-Davis Co., Kalamazoo, Mich., at $750,000. Estimated cost including equipment $2,750,000.

Ga., Rome—Tubize-Chatillon Co., c/o R. C. Jones, Rome, has awarded the contract for superstructure of 100x800 ft. viscose plant to A. K. Adams & Co., 452 Plum St., N. W., Atlanta. Same contractor also received contract for substructure. Estimated cost $500,000.

Ia., Des Moines—Marquette Cement Manufacturing Co., 140 South Dearborn St., Chicago, Ill., has awarded the contract for a warehouse at 52nd St. and Park Ave., to Arthur H. Neumann & Bros., 514 Hubbell Bldg., at $279,536.

Ky., Louisville—E. I. du Pont de Nemours & Co., Wilmington, Del., will construct a neoprene synthetic rubber plant here to have a capacity of 10,000 long tons a year. Construction will start immediately. Estimated cost $10,000,000.

Mo., St. Louis—Orchard Paper Co., 3914 Union Blvd., has awarded the contract for a 1 story, 80x200 ft. addition to its warehouse to Brown & Ideson, Inc., 4914 Gravois Ave., St. Louis. Estimated cost $40,000.

N. J., Newark—Hanovia Chemical & Manufacturing Co., 233 New Jersey Railroad Ave., has awarded the contract for a brick and steel chemical factory to Wininger, Selby & Herrick, Inc., 152 West 42nd St., New York, N. Y. Estimated cost $50,000.

N. J., Rahway—Merck & Co., 126 East Lincoln Ave., has awarded the contract for additional plant facilities to Walter Kidde Constructors, Inc., 140 Cedar St., New York, N. Y. Estimated cost $150,000.

N. M., Artesia—Maljamar Oil Corp., Artesia, has awarded the contract for a repressuring plant system and casinghead gasoline plant to Frick-Reid Supply Corp., 108 North Trenton St., Tulsa, Okla. Estimated cost $190,000 and $102,000 respectively.

N. M., Santa Fe—Sanders Bros., Placita Rafaela, have awarded the contract for a repressuring plant to Loco Hills Pressure Maintenance Assn., Inc, Santa Fe and Loco Hills. Estimated cost $140,000.

N. Y., Suffern—Allied Products, Inc., cosmetics manufacturers, has awarded the contract for a 5 story, 80x100 ft. warehouse here to W. J. Barney Corp., 101 Park Ave., New York, N. Y. Estimated cost $90,000.

N. Y., Wellsville—Sinclair Refining Co., Wellsville, has awarded the contract for a 1 story addition to its crude oil refinery to L. C. Whitford Estate, Wellsville. Estimated cost including equipment $50,000.

O., Cleveland—Harshaw Chemical Co., 1945 East 97th St., has awarded the contract for a 1 story, 80x261 ft. factory addition to H. L. Vokes Co., 5300 Chester Ave., Cleveland. Estimated cost $50,000.

O., Elyria—Harshaw Chemical Co., C. E. Cowser in charge, 1945 East 97th St., Cleveland, has awarded the contract for a 1 story, 50x300 ft. factory to H. L. Vokes Co., 5300 Chester Ave., Cleveland. Estimated cost $50,000.

Ore., Portland—Portland Gas & Coke Co., Public Service Bldg., has awarded the contract for an addition to its chemical and gas plant on N. W. St. Helen's Rd., to Bechtel-McCone-Parsons Corp., 601 West 5th St., Los Angeles, Calif. Contract for 4 Knowles coke ovens has been let to H. A. Brassert & Co., 60 East 42nd St., New York, N. Y. Estimated cost $1,500,000.

Pa., Emlenton—Quaker State Oil Refining Corp., B. G. Hunter, Gen. Supt., will rebuild its filter house. Work will be done by separate contracts. Estimated cost will exceed $40,000.

Pa., Pittsburgh—United Drug Co., 43 Leon St., Roxbury, Mass., has awarded the contract for a 3 story, 125x200 ft. warehouse here to Mellon-Stuart Co., 210 East Parkway, N. S., Pittsburgh. Estimated cost $200,000.

Tenn., Chattanooga—War Dept., Wash., D. C., has awarded the contract for constructing and operating a plant to manufacture coke for the production of aluminum, etc., to Tennessee Products Corp., Alton Park, Chattanooga, at $1,816,800. Defense Plant Corp. will finance.

Tex., Ganado—H. B. Zachry & Co., Laredo, Tex., and Larry Cox and Associates, Petroleum Bldg., Houston, Tex., has awarded the contract for the construction of a recycling plant in the Francitas Fields, Jackson Co., near Ganado, to H. B. Zachry Construction Co., Laredo, and Builders Exchange, San Antonio, at $620,000. Total estimated cost $1,250,000.

Tex., Port Isabel—Coastal Refinery will construct an additional unit at its refinery here including installation of rectification units. Work will be done by force account and subcontracts. Estimated cost $100,000.

Tex., San Antonio—Crocket Laboratories, Inc., 1818 Kentucky St., has awarded the contract for a 2 story, 80x140 ft. laboratory to J. H. Rayburn, 1818 Kentucky St. Estimated cost $40,000.

Wash., Camas—Crown Willamette Paper Co., Pittock Block, Portland, Ore., has awarded the contract for a 4 story, 110x120 ft. converting plant addition to Reimers & Jolivette, Railway Exchange Bldg., Portland. Estimated cost $40,000.

Wash., Spokane—Lehigh Portland Cement Co., Old Natl. Bank Bldg., has awarded the contract for a 2 story, cement storage plant to S. G. Morin, 309 Bernard St. Estimated cost $70,000.